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COMPARATIVE VERIFICATION OF GUIDANCE AND LOCAL AVIATION/PUBLIC WEATHER FORECASTS--NO. 9
(October 1979 - March 1980)

Joseph R. Bocchieri, J. Paul Dallavalle, Karl L. Hebenstreit,
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1. INTRODUCTION

This is the ninth in the series of Techniques Development Laboratory (TDL) office notes which compare the performance of TDL's automated guidance forecasts with National Weather Service (NWS) local forecasts made at Weather Service Forecast Offices (WSFO's). The local forecasts, which are produced subjectively, may or may not be based on the automated guidance. We present verification statistics for the cool season months of October 1979 through March 1980 for probability of precipitation, precipitation type, surface wind, opaque sky cover, ceiling height, visibility, and maximum/minimum (max/min) temperature.

The objective guidance is based on equations developed through the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972). We derived these prediction equations by using archived surface observations and forecast fields from the Limited-area Fine Mesh (LFM) model (National Weather Service, 1971), the LFM-II model (National Weather Service, 1977a), the Trajectory (TJ) model (Reap, 1972), and/or the 6-layer coarse mesh Primitive Equation (6LPE) model (Shuman and Hovermale, 1968). In operations, however, forecast fields from the LFM-II and the 7-layer PE (7LPE) model[1] (National Weather Service, 1977b) are employed in the MOS guidance equations when LFM or PE data, respectively, are required. Unless indicated otherwise, we usually refer to MOS forecasts based on the LFM-II as "early" guidance; "final" guidance indicates that the objective forecasts were dependent on the 7LPE. Also, the observation times of surface weather elements used as predictors in the early and final guidance generally differ.

The local forecasts from the WSFO's were collected by the Technical Procedures Branch of the Office of Meteorology and Oceanography for the purposes of the NWS combined aviation/public weather verification system (National Weather Service, 1973). These forecasts were recorded for verification according to the direction that they be "...not inconsistent with..." the official weather prognosis. Surface observations as late as 2 hours before the first valid forecast time may have been used in the preparation of the local forecasts. We obtained the observed verification data from the National Climatic Center in Asheville, North Carolina.

2. PROBABILITY OF PRECIPITATION (PoP)

The objective PoP forecasts were produced by the cool season prediction equations described in Technical Procedures Bulletin No. 244 (National Weather Service, 1978a). Guidance was available for the first, second, and third periods, which correspond to 12-24, 24-36, and 36-48 hours, respectively, after

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1 In August 1980, the 7LPE model was replaced in operations by the Spectral model (Sela, 1980).

model input data time (0000 or 1200 GMT). The predictors for the first period equations were forecast fields from the LFM-II model and surface variables observed at the forecast site 3 hours after the initial model time.

Both early and final objective guidance were produced for the second and third periods while only early guidance was available for the first period. All of the early automated forecasts were based on the LFM-II model. The final guidance for the second period was based on fields from the LFM-II, 7LPE, and TJ models. Third period final guidance equations used 7LPE predictors only.

We verified the forecasts by computing the Brier score (Brier, 1950) for the 87 stations shown in Table 2.1. Please note that we used the standard NWS Brier score which is one-half the original score defined by Brier. Brier scores will naturally vary from one station to the next and from one year to the next because of changes in the relative frequency of precipitation. Therefore, we also computed the percent improvement over climate; that is, the percent improvement of the Brier scores obtained from the local or guidance forecasts over the Brier scores produced by climatic forecasts. The latter are defined as relative frequencies of precipitation by month and by station determined from a 15-year sample (Jorgensen, 1967).

Table 2.2 shows the results for all 87 stations for 0000 GMT forecasts made during the period October 1979 through March 1980. Tables 2.3 through 2.6 show scores for the NWS Eastern, Southern, Central, and Western Regions, respectively; the second and third period verifications are a three-way comparison between the early and final guidance, and the local forecasts.

The results for all 87 stations show that the local forecasts improved upon both the early and final guidance for all three periods. By NWS regions, this was true for the Central and Western Regions and, except for the second period early guidance, it was true for the Eastern Region. On the other hand, forecasters in the Southern Region did not improve upon the early guidance for the second and third periods but did improve upon the final guidance. Note in Table 2.4 the very large improvements over climate for both the local forecasts and guidance in the Southern Region for the first and third period. This large improvement may be partially due to the fact that the Southern Region experienced a drier than usual cool season in 1979-80 than in previous years. The relative frequencies of _ .01 inch in the 12-h periods were smaller in 1979-80 than the climatic frequency based on many years of data. Thus, there was a deterioration in the climatic Brier scores.

Another important result is that the early guidance continued to be more accurate than the final guidance for both the second and third periods. The only exception to this occured in the Western Region where the second and third period final MOS forecasts were more accurate. The superiority of the early over the final guidance decreased since the last cool season (Hebenstreit et.al., 1979).

Figure 2.1 shows the trend since 1970-71 in the accuracy (expressed in terms of percent improvement over climate) of the first and third period 0000 GMT PoP forecasts. During the 1979-80 cool season, the local forecasts and the early guidance were more accurate for the first period than in any previous season. Recall that starting with the cool season 1977-78 the final and early guidance have been identical for the first period. For the third period, the local, early, and final guidance forecasts were more accurate than in any previous season. In fact, all three third period forecasts in 1979-80 were at least as accurate as the first period final guidance in 1974-75. The first and third period improvement in 1979-80 is because of the abnormally large improvement in the Southern Region for those periods; the second period showed no such improvement.

3. PRECIPITATION TYPE

The early guidance conditional probability of precipitation type (PoPT) forecast system (Bocchieri, 1979) gives forecasts for three categories: frozen (snow or ice pellets), freezing (freezing rain or drizzle), and liquid (rain). Precipitation in the form of mixed snow and ice pellets is included in the frozen category; all other mixed precipitation types are included in the liquid category. Here, the frozen, freezing, and liquid categories will be referred to as simply snow, freezing rain, and rain, respectively.

In the final guidance conditional probability of frozen precipitation (PoF) system (Glahn and Bocchieri, 1975; Bocchieri and Glahn, 1976; and National Weather Service, 1976), freezing rain forecasts aren`t explicitly available; that is, freezing rain is considered as rain in PoF. Another difference between the PoPT and PoF systems is that in PoPT probability forecasts are transformed so that a "best category" is also provided operationally; in PoF, a categorical forecast isn`t available.

In the NWS verification, local categorical forecasts of precipitation type made at about 1000 GMT are recorded for the valid times 1800 GMT (today), 0600 GMT (tonight), and 1800 GMT (tomorrow). Note that this is a conditional forecast; that is, it`s a forecast of type of precipitation if precipitation occurs. Therefore, a precipitation type forecast is always recorded. The PoPT and PoF guidance forecasts are also conditional and are available whether or not precipitation occurs.

Table 3.1 lists the 62 stations used in this verification. We included only cases when precipitation actually occurred. We were concerned that the forecasters may not have put much effort into making the conditional forecasts when they considered precipitation to be unlikely. Therefore, in order to isolate those situations when the forecaster thought precipitation a definite possibility, we used only the cases when the local PoP was _ 30%. The PoPs were valid for the 12-h periods centered on the 18-, 30-, and 42-h projections used in the verification.

We first did a comparative verification between the early PoPT guidance and the local forecasts for the snow, freezing rain, and rain categories. The manner in which the guidance "best category" is calculated is described in Bocchieri (1979). Table 3.2 shows the verification results; note that the scores for the freezing rain category are not shown for this season because there weren`t enough cases to be meaningful. The results for all stations combined indicate that: (1) the guidance was better than the local forecasts for percent correct and skill score[2] for the 18- and 30-h projections. At 42 hours, there was little

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[2]The skill score used throughout this paper is the Heidke skill score (Panofsky and Brier, 1965).

difference between the two; (2) as shown by the bias[3], the guidance (local forecast) tended to slightly overforecast (underforecast) the snow event. These results were generally true in the regional breakdown except that, in the Western Region, there was little difference between the guidance and local forecasts for all three projections, and, in the Southern Region, the local forecasts were better than the guidance at 42 hours.

The percent correct and skill scores were very high because the sample included many "obvious" forecasts. For instance, on some days in the southern states, precipitation, if it occurred, would obviously be rain. In order to isolate some of the more difficult forecasting situations, we looked at the cases in which the guidance and local forecasts differed. Again we used only those cases for which local PoPs were ≥ 30%. The results in Table 3.3 indicate that for the 18-h projection, the guidance was correct about 74% of the time while the local forecasts were correct about 26% of the time. The advantage of the guidance over the local forecasts decreased with projection so that by 42 hours there was little difference between the two.

In order to do a comparative verification between the early PoPT guidance, the final PoF guidance, and the local forecasts and to compare scores from the 1979-80 season to previous seasons, we also verified two categories of precipitation type: snow and rain. In this verification, freezing rain was included in the rain category. A PoF categorical forecast of snow was defined as a PoF ≥ 50%. In the PoPT system, categorical forecasts of snow were available operationally. In Table 3.4, the verification results for all stations combined indicate that: (1) the early guidance was generally better than the final guidance and the local forecasts for all scores and projections: (2) the final guidance was generally better than the local forecasts except in terms of bias; and (3) except at the 30-h projection, the guidance systems (local forecasts) tended to overforecast (underforecast) the snow event. These results were also generally true in the regional breakdown except that there was little difference between the local and guidance forecasts at 18 and 30 hours in the Western Region and at 42 hours in the Eastern Region. Also, in the Southern Region, local forecasts were better than the early guidance at 42 hours.

The skill scores of the guidance and local forecasts for 7 seasons are shown in Fig. 3.1. Only the 18- and 42-h verification results are presented. Note that some changes in the verification procedure took place during these 7 years. First, the number of stations changed from approximately 90 for the first 2 years to approximately 60 afterwards. Secondly, starting with the 1975-76 season, we used only cases when the local PoP was 30% or greater in order to isolate those cases when the forecaster would have been more confident that precipitation was to occur. Third, starting in the 1976-77 season, we verified the early PoF guidance for the 18-h projection. Finally, in the 1978-79 season, the early PoF system was replaced by the PoPT system, and the PoPT forecasts were verified for both the 18- and 42-h projections.

The results indicate that the guidance was consistently better over the 7 years except during the 1977-78 seasons when guidance and local forecasts scored the same at the 18-h projection. Note that the PoPT system, which

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[3]The bias is the number of forecasts of an event divided by the number of observed events.

replaced the early PoF system in the 1978-79 season, was better than the final PoF guidance for the 1978-79 and 1979-80 seasons and for both projections. Also, the skill of all systems, except the 18-h local forecasts, improved in 1979-80 as compared to the previous season, especially at the 42-h projection.

4. SURFACE WIND

The cool season objective wind forecasts were generated by LFM-based (early) equations (National Weather Service, 1980). These equations do not include surface weather observations as predictors. Wind guidance produced by final equations was terminated in May 1979, so the final guidance was not verified for the 1979-80 cool season. We only verified the 18-, 30-, and 42-h forecast projections from 0000 GMT. Note that the definition of the objective surface wind forecast is the same as that of the observed wind: the one-minute average direction and speed for a specific time.

Two factors may have had an impact on this verification. First, the equations used for this cool season were new. These relationships were derived from an improved version of our screening regression program that reduced the instances when highly related predictors were selected in an individual equation. Equations derived in this manner should produce more accurate forecasts. Secondly, the LFM model topography was changed in October 1979. This modification drastically altered some model surface pressure forecasts, especially in the West. Unfortunately, surface pressure had been selected as a predictor in some of the forecast equations. Therefore, it is possible that poor guidance for some western U.S. locations was produced. However, it is also possible that the improved method of equation development mentioned above may have masked some of the deleterious effects of the model topography change.

Since the local forecasts were recorded as calm if the wind speed was expected to be less than 8 knots, we verifed the wind forecasts in two ways. First, for all those cases where both the local and guidance wind speed forecasts were at least 8 knots, the mean absolute error (MAE) of speed was computed. Secondly, for all cases where both local and guidance forecasts were available, the skill score, percent correct, and bias by category were computed from contingency tables of wind speed. The seven categories were: less than 8, 8-12, 13-17, 18-22, 23-27, 28-32, and greater than 32 knots. Table 4.1 lists the 94 stations used in the verification. Tables 4.2-4.12 show comparative verification scores for the 18-, 30-, and 42-h projections. It should be noted that all the guidance forecasts of wind speed were adjusted by an "inflation" equation (Klein et al., 1959) involving the multiple correlation coefficient and mean value of wind speed for a particular station and forecast valid time.

The results for all 94 stations combined are shown in Tables 4.2 and 4.3. The direction MAE scores reveal an advantage for the guidance that is approximately 5^{o} for all three forecast projections combined. Overall, the speed MAE's, skill scores, and percent correct were also better for the guidance. Both the biases by category in Table 4.2 and the contingency tables in Table 4.3 indicate that the guidance underestimated winds stronger than 32 knots (category 7) at the 18- and 42-h projections. Winds stronger than 22 knots (categories 5, 6, and 7) were underestimated by the guidance at the 30-h projection. For most categories, the guidance exhibited better bias characteristics than the local forecasts. In fact, the biases of the guidance wind speed forecasts for this cool season were the best of any of the previous 6 cool seasons (see, for example, Hebenstreit et al., 1979).

Tables 4.4-4.7 show verifications for the NWS Eastern, Southern, Central, and Western Regions, respectively. The regional scores had the same general characteristics as the national; however, the magnitude of the advantage of the guidance over the local forecasts varied from region to region. With few exceptions, the guidance forecasts were consistently superior to the local forecasts at all projections.

Table 4.8 shows the distribution of wind direction absolute errors by categories--0-30°, 40-60°, 70-90°, 100-120°, 130-150°, and 160-180°--for all 94 stations combined. Note that the guidance had about 5% fewer errors of 40° or more than did the local forecasters for the 18-h projection. The improvement of the guidance over the local forecasts were 6% and 8% for the 30- and 42-h projections, respectively.

Distribution of direction errors for individual regions are given in Tables 4.9-4.12. In general, these results are much like those in Table 4.8, except that, once again, the magnitude of the advantage of the guidance over the local forecasts differs from region to region. The 18-h local and guidance forecasts for the Western Region had nearly the same percentage of errors greater than 40°.

A comparison of the overall MAE`s and skill scores for the past 7 cool seasons for the 18- and 42-h guidance and local forecasts is presented in Figs. 4.1-4.4. In general, the verification data throughout this period were homogeneous, with the exception of the cool season of 1973-74 which did not include the month of October. The number of stations varied only slightly from season to season, and the same basic set of verification stations was used. The 18-h early guidance forecasts became operational at the beginning of the 1978-79 cool season. Since the final guidance was abandoned in 1979, Figs. 4.1-4.4 do not show verification results of the final forecasts beyond the 1978-79 cool season.

The MAE`s for direction are shown in Fig. 4.1. Except for a slight increase in some of the MAE`s during the 1977-78 and 1979-80 cool seasons, the guidance and local forecasts for both projections have generally improved over the span of these 7 cool seasons.

In contrast, the MAE`s in Fig. 4.2 indicate a decrease in accuracy for the final guidance speed forecasts between the 1974-75 and 1975-76 cool seasons. This was caused by the introduction of inflation in August of 1975. We realized that inflation would have this effect; however, previous wind speed verifications indicate that the bias values of inflated forecasts are somewhat closer to 1.0 compared to the bias of uninflated forecasts (Carter and Hollenbaugh, 1976). As shown earlier in Table 4.2, the biases of the guidance forecasts in the 1979-80 cool season were quite close to 1.0. Note that the 18-h early guidance MAE`s are now identical to the pre-inflated levels. Also note the superiority of the early guidance forecasts over both the final guidance and local forecasts prior to the 1979-80 cool season. For this reason, the final guidance was terminated.

Fig. 4.3 is a comparison of guidance and local skill scores computed on five (instead of seven) categories; the fifth category included all speeds greater than 22 knots. Of particular note in Fig. 4.3 is the magnitude of the advantage in skill of the guidance over the locals for both projections. With the exception of the 1978-79 final guidance skill scores, the guidance out-performed the local forecasts throughout the past 7 seasons. The early guidance and local skill scores generally improved from the 1978-79 to the 1979-80 cool season.

Fig. 4.4 depicts a comparison of guidance and local skill scores computed on two categories; the first category contained all speeds less than or equal to 22 knots, while the second category included speeds greater than 22 knots. In this manner, we attempted to assess more directly the skill of the guidance and local forecasts in regard to predicting strong winds. Similar to the results in Fig. 4.3, the skill of both the guidance and local forecasts increased from the 1978-79 to the 1979-80 season. Again, the early guidance scores exhibit a clear superiority over the local forecasts, particularly in the 1979-80 season.

The early guidance MAE`s and skill scores in Fig. 4.1-4.4 generally indicate the superiority of these forecasts over the final guidance. This is quite encouraging because the early guidance is now the only source of detailed surface wind guidance available to NWS field forecasters prior to issuance of the public weather forecast.

5. OPAQUE SKY COVER

The early guidance equations used in forecasting opaque sky cover were unchanged for the 1979-80 cool season; the equations used LFM-II model output and 0300 (1500) GMT surface observations to produce forecasts for eight projections at 6-h intervals from 6 to 48 hours after 0000 (1200) GMT. Final opaque sky cover guidance was terminated at the start of the 1979-80 cool season and, hence, was not verified.

The regionalized equations produced probability forecasts of four categories of opaque sky cover, more commonly known as cloud amount, as shown in Table 5.1. The probability estimates were converted to a single "best" category forecast in a manner which produced good bias characteristics, that is, a bias value of approximately 1.0 for each category. For more details about our cloud amount forecast system, see Technical Procedures Bulletin No. 234 (National Weather Service, 1978b).

We compared the local forecasts with a matched sample of early guidance forecasts at the 94 stations listed in Table 4.1 for the 18-, 30-, and 42-h forecast projections from the 0000 GMT cycle only. The local forecasts and the surface observations used for verification were converted from opaque sky cover amount to the categories in Table 5.1. Four-category, forecast-observed contingency tables were prepared from the transformed local and best-category objective predictions. Using these tables, we computed the percent correct, skill score, and bias by category.

The results for all stations combined are shown in Table 5.2. At the 30- and 42-h projections, the guidance forecasts were clearly superior to the local forecasts in terms of percent correct and skill score. However, the differences at the 18-h projection were small. Examination of the bias-by-category scores shows that, at each projection and category, the guidance forecasts were better (i.e., closer to 1.0) than the local forecasts. The local forecasts exhibited a strong tendency to overforecast the scattered and broken categories and to a lesser degree to underforecast the clear and overcast categories.

The verification scores for stations in the NWS Eastern, Southern, Central, and Western Regions are given in Tables 5.3 through 5.6, respectively. The percent correct and skill scores for the guidance forecasts were, for the most part, superior to those of the local forecasts. At the 18-h projection, the skill score for the Central Region was slightly better than that of the guidance and, in the

Western Region, both the percent correct and skill score were superior. The bias scores for the guidance forecasts were generally better than those for the local forecasts in the regional breakdown. They also show that the general tendency to overforecast scattered and broken conditions occurred in all regions.

The percent correct and skill scores over the past 6 cool seasons are shown in Figs. 5.1 and 5.2, respectively, for the 18- and 42-h projections. These figures show that, following a relatively good 1978-79 cool season, both the guidance and the local forecasts deteriorated to a level more comparable to earlier years.

Figs. 5.3 through 5.6 show the biases for categories 1 through 4, respectively, for the 18- and 42-h projections. As can be seen, in all cases the guidance bias scores have been consistently superior to those of the local forecasts. The local forecasts underforecast the clear (category 1) and overcast (category 4) categories and overforecast the scattered (category 2) and broken (category 3) categories. Note that the 42-h early guidance was not implemented until January 25, 1978. Therefore, the matched sample size for the early and final guidance and local forecasts covered only about 2 months rather than 6. This small sample size may be responsible for the unusually high category 3 bias for the guidance.

6. CEILING AND VISIBILITY

For the 1979-80 cool season, we used the ceiling and visibility prediction equations first implemented in February 1977. Operationally, the early guidance set is driven by LFM-II model output and uses 0300 (1500) GMT surface observations. The guidance consists of forecasts at 6-h intervals from 6 to 48 hours after cycle time. For details concerning the ceiling and visibility forecast system see Technical Procedures Bulletin No. 234 (National Weather Service, 1978b).

Our ceiling and visibility verification procedure continues to track the performance of a number of scores for both local and guidance forecasts. In each case a persistence observation (taken at 0900 GMT for the 0000 GMT cycle and at 2100 or 2200 GMT for the 1200 GMT cycle) provides a comparison. Guidance forecasts are verified for both cycles at the 12-, 18-, 24-, 36-, and 48-h projections and local forecasts for 12-, 15-, and 21-h projections. The guidance and the persistence observation are usually available to the local forecaster.

We constructed six-category (Table 6.1) forecast-observed contingency tables for all forecasts involved in the comparative verification. The entries in these tables were then used for computing several different scores: bias-by-category, percent correct, and skill score. We then collapsed the tables to two categories (categories 1 and 2 combined versus categories 3 through 6 combined) and calculated the bias and threat score for categories 1 and 2 combined and the skill score and percent correct for the reduced tables. The results are summarized in Tables 6.2-6.9. The skill score and bias for categories 1 and 2 combined are also given in Figs. 6.1-6.8 for selected projections for the last 5 cool seasons.

Tables 6.2-6.5 present the results for the six-category ceiling and visi- bility forecasts for all 94 stations (see Table 4.1) combined, and Tables 6.6-6.9 provide scores for categories 1 and 2 combined (i.e., ceilings less than 500 feet and visibilities less than 1 mile). The skill of the local forecasts for both the six-category and two-category tables exceeded that of the guidance at the 12-h projection. However, with the exception of the six-category ceiling for the 1200 GMT cycle, the skill of persistence exceeded that of the local forecast at the 12-h projection for both cycles for both ceiling and visibility. At the 15- and 21-h projections, the six-category skill of the local forecast was greater than persistence except for visibility at 15-h from the 1200 GMT cycle. The two-category persistence skill exceeded that of the locals at the 15- and 21-h projections for the 0000 GMT cycle and for ceiling at the 15-h projection for the 1200 GMT cycle. The guidance forecast six-category skill was less than persistence for visibility at the 18-h projection for both cycles and at the 36-h projection for the 0000 GMT cycle. Guidance two-category skill lost to persistence for ceiling at the 18-h projection for both cycles and for visibility at the 36-h projection for the 0000 GMT cycle. For all other projections the skill of the guidance exceeded that of persistence for both the two and six-category tables with the skill of persistence decreasing more rapidly with the time of the projection.

The purpose of using the threshold probability technique to select the "best" category for ceiling and visibility was to improve the bias characteristics of the guidance forecasts. The bias-by-category scores show that for most projections the guidance had better bias scores (i.e., were closer to 1.0) than either the local or persistence forecasts. The bias of the 12-h persistence (actually 3-h from observation) is better than that of either the locals or guidance. The biases of the 36-h persistence forecasts (actually a 27-h projection) should be as good as those of 12-h persistence. Tables 6.2-6.9 show this to be true.

Figs. 6.1 to 6.8 present the year-to-year variations of two-category skill and bias for projections of 12-, 15-, 18-, and 21-h for the 0000 GMT cycle. In general, these data show that the guidance bias characteristics for the difficult-to-forecast low categories were closer to the desired 1.0 than local and persistence forecasts since the implementation of the threshold technique of best category selection in February 1977. The skill score for guidance forecasts exhibits variation from year-to-year. Since the sample size for the 1976-77 cool seasons (Feb 8 to Mar 31) was relatively small, the scores fluctuate in most of the graphs for that season. We note the precipitous drop in skill for the 18-h projection for ceiling. This trend is also noted for longer projections and may be attributable to the fact that the equations were developed on only 4 years of LFM (1972-76) data but are now using values from the LFM II fields.

7. MAX/MIN TEMPERATURE

The objective max/min guidance for October 1979 through March 1980 was generated by several different sets of regression equations. However, the predictand for both the early and final guidance was the local calendar day max or min valid approximately 24, 36, 48, and 60 hours after initial model time (0000 or 1200 GMT). The final automated forecasts were based on equations developed by stratifying archived 6LPE and TJ model output, station observations, and the first two harmonics of the day of the year into seasons of 3-month duration (Hammons et al., 1976). We used fall (September-November), winter (December-February), and spring (March-May) equations to produce the final guidance during the appropriate months of the 1979-80 cool season. Operationally, the equations employed output from the 7LPE and the TJ models as predictors. Station observations taken 6 hours after the initial model time also were used in the final guidance equations for the first two projections.

In contrast, the early guidance system depended on prediction equations derived from LFM model output, station observations available 3 hours after initial model time, and the first two harmonics of the day of the year (Carter et al., 1979).

For the first projection, forecast equations were available for 3-month seasons: fall (October-December) and winter (January-March). After the first projection, however, we had enough data only for 6-month season equations. Thus, the early guidance for the second, third, and fourth projections relied on cool season (October-March) equations. In operations, forecast fields from the LFM-II were employed as predictors in the LFM-derived equations. Surface observations at 3 hours after the initial model time were used as input to many of the forecasts for the first two periods.

As discussed earlier, the automated max/min forecasts are for the local calendar day. Thus, for example, the first period objective forecasts of the max based on 0000 GMT model data is valid for the calendar day that starts at midnight following 0000 GMT and that ends 24 hours later. However, the valid period of the local max/min forecast does not correspond to the calendar day. Rather, the local forecaster predicts a max more nearly corresponding to the daylight hours and an "overnight" min. Hence, caution is necessary in comparing verification scores for the local forecasts and the objective guidance.

We verified local and objective forecasts from the 0000 GMT cycle, using calendar day max and min temperatures obtained from the National Climatic Center as the verifying observations. Mean algebraic error (forecast minus observed temperature), mean absolute error, and the number of absolute errors greater than or equal to 10°F were computed for 87 stations (Table 2.1) in the conterminous United States. Four forecast projections of approximately 24 (max), 36 (min), 48 (max), and 60 (min) hours after 0000 GMT were verified.

Verification results are shown in Table 7.1 for all stations combined. For both the 24- and 48-h max, the early guidance was clearly superior to the final in terms of mean algebraic error, mean absolute error, and the number of large absolute errors (_ 10°F). For the 36-h min, both sets of guidance were approximately equal in accuracy. However, the final guidance was better in predicting the 60-h min. These results are quite similar to those seen for the 1978-79 cool season (Hebenstreit et al., 1979). We've noted before (Hammons et al., 1976) that the min is more difficult to predict during the colder months than the max. We believe that this tendency combined with the small sample (2 years) and the 6-month seasons used for the early guidance equations is responsible for the early guidance being less accurate than the final for the 60-h min. With updated LFM equations being developed and implemented (Dallavalle et al., 1980) the differences in the two types of guidance at 60 hours will likely disappear.

As Table 7.1 demonstrates, the local forecasts were more accurate than either the early or final guidance in terms of mean absolute error and the number of large absolute errors. In fact, the improvement of the local forecasts over the early was 0.3°F mean absolute error averaged over the four projections as compared to 0.1°F in the 1978-79 cool season (Hebenstreit et al., 1979). Moreover, the local forecasts generally had smaller biases (mean algebraic errors) than the guidance. In nearly all cases, both the objective and local forecasts showed a cold bias (negative algebraic errors).

Tables 7.2-7.5 give the verification scores for the Eastern, Southern, Central, and Western Regions, respectively. Generally, the regional results follow the national trends discussed above. In short, in all regions, the early guidance was usually more accurate than the final for the first three projections. The superiority of the early guidance was greatest for the 24-h max. In contrast, the final guidance was more accurate for the 60-h min, particularly in the Central and Western Regions. In every region but the Eastern, the local forecasts improved upon the objective guidance at all four projections. For the Eastern Region, the early guidance and the local forecasts were equally accurate in the first three projections. In all regions, the local forecasts of the 60-h min were substantially more accurate than the early guidance.

The mean absolute errors (0000 GMT cycle only) during the last 9 cool seasons are given in Fig. 7.1 for the max forecasts. For both the local forecasts and final guidance, there has been an overall increase in accuracy since the 1971-72 cool season. The greatest improvement in the objective guidance occurred in the 1973-74 cool season with the implementation of the first MOS forecast equations based on 6-month seasons (Klein and Hammons, 1975). The introduction of LFM-derived early guidance equations in the 1978-79 cool season narrowed the gap between the local forecasts and the guidance although the local forecasts increased the margin of improvement in the 1979-80 cool season.

An analogous time series is shown in Fig. 7.2 for the min forecasts. Verifications for the 60-h projection are available only for the last 3 seasons. For the 36-h projection, there has been an overall improvement in both the local forecasts and the objective guidance. Certainly, natural variability and the difficulty of predicting the min during the cool season accounts for the irregular manner of the improvement. Unlike the max, the objective min guidance showed its greatest increase in accuracy in the 1975-76 cool season when we switched from 6-month to 3-month MOS forecast equations (Hammons et al., 1976). For the first time, for both the 36- and 60-h projections, the local forecasts showed more skill than all available guidance in the 1979-80 cool season.

8. CONCLUSIONS

This verification indicates that both guidance and local forecasts generally showed improvement in the 1979-80 cool season as compared to the previous cool season for PoP, precipitation type, surface wind speed and max/min temperatures. In PoP, for instance, it's notable that both the guidance and local third period forecasts were at least as accurate as the first period final guidance in 1974-75. The scores for surface wind direction, opaque sky cover, ceiling, and visibility were generally about the same or worse during the 1979-80 cool season than in the previous season.

The local PoP forecasts for the 1979-80 cool season generally improved upon the guidance, especially in the Central and Western Regions and for the first period. For both the second and third periods, the early guidance PoP was better than the final guidance in all regions except in the Western Region where the final guidance was superior.

The early and final precipitation type guidance was generally better than the local forecasts, except in the Western Region where there was little difference between the scores. The early guidance was generally better than the final guidance for all projections.

The guidance wind speed and direction forecasts were generally more accurate than the local forecasts in both the national and regional verifications. The bias characteristics of the guidance wind speed forecasts improved during the 1979-80 cool season and, in fact, were the best of any of the previous 6 cool seasons.

The various performance measures show that the early guidance forecasts of opaque sky cover were, for the most part, more accurate than the local forecasts. The only exception was for the 18-h skill score where the local forecasts were slightly better than the guidance. The bias characteristics of the guidance were better than the local forecasts which tended to underforecast the clear and overcast categories and overforecast the scattered and broken categories.

A direct comparison between local, guidance, and persistence forecasts for ceiling and visibility was possible only at the 12-h projection. At this projection, the local forecasts were more skillful than guidance, but, in both the two and six-category comparison, persistence was generally more skillful than the local forecasts. The long term trend generally shows a decrease in skill in predicting low conditions for the guidance forecasts. The bias characteristics of the guidance continued generally better than the locals in the lower categories, where the local forecasts tend to underforecast the occurrence of these events.

For the max/min temperature, the early guidance was more accurate than the final for the 24-, 36-, and 48-h projections; for the 60-h min, the opposite was true. These same results were generally evident in the four NWS regions. Though comparisons between the objective guidance and the local max/min forecasts are difficult to make because of the different forecast periods involved, we found that the local forecasts generally improved upon the early or final guidance at all four forecast projections.

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Table 2.1. Eighty-seven stations used for comparative verification of automated and local PoP and max/min temperature forecasts.

AVL	Asheville, North Carolina	DFW	Dallas-Ft. Worth, Texas
RDU	Raleigh-Durham, North Carolina	JAN	Jackson, Mississippi
ORF	Norfolk, Virginia	MIA	Miami, Florida
PHL	Philadelphia, Pennsylvania	ORL	Orlando, Florida
RIC	Richmond, Virginia	TPA	Tampa, Florida
DCA	Washington, D.C.	MSY	New Orleans, Louisiana
CRW	Charleston, West Virginia	BRO	Brownsville, Texas
CHS	Charleston, South Carolina	SAT	San Antonio, Texas
CLT	Charlotte, North Carolina	IAH	Houston, Texas
CAE	Columbia, South Carolina	ATL	Atlanta, Georgia
LGA	New York (Laguardia), New York	BHM	Birmingham, Alabama
BUF	Buffalo, New York	JAX	Jacksonville, Florida
ALB	Albany, New York	MEM	Memphis, Tennessee
BOS	Boston, Massachusetts	SHV	Shreveport, Louisiana
BDL	Hartford, Connecticut	AUS	Austin, Texas
BTV	Burlington, Vermont	LIT	Little Rock, Arkansas
PWM	Portland, Maine	OKC	Oklahoma City, Oklahoma
PVD	Providence, Rhode Island	TUL	Tulsa, Oklahoma
SYR	Syracuse, New York	MAF	Midland, Texas
CLE	Cleveland, Ohio	ELP	El Paso, Texas
CMH	Columbus, Ohio	AMA	Amarillo, Texas
BWI	Baltimore, Maryland	ABQ	Albuquerque, New Mexico
ACY	Atlantic City, New Jersey	FLG	Flagstaff, Arizona
CVG	Cincinnati, Ohio	TUS	Tucson, Arizona
DAY	Dayton, Ohio	LAS	Las Vegas, Nevada
PIT	Pittsburgh, Pennsylvania	LAX	Los Angeles, California
ICT	Wichita, Kansas	RNO	Reno, Nevada
MCI	Kansas City, Missouri	SAN	San Diego, California
STL	St. Louis, Missouri	SFO	San Francisco, California
MDW	Chicago (Midway), Illinois	BIL	Billings, Montana
MKE	Milwaukee, Wisconsin	SLC	Salt Lake City, Utah
SSM	Sault Ste Marie, Michigan	BOI	Boise, Idaho
DLH	Duluth, Minnesota	HLN	Helena, Montana
FAR	Fargo, North Dakota	GEG	Spokane, Washington
MSP	Minneapolis, Minnesota	PDX	Portland, Oregon
DSM	Des Moines, Iowa	SEA	Seattle-Tacoma, Washington
OMA	Omaha, Nebraska	CPR	Casper, Wyoming
FSD	Sioux Falls, South Dakota	RAP	Rapid City, South Dakota
DEN	Denver, Colorado	IND	Indianapolis, Indiana
BIS	Bismarck, North Dakota	SDF	Louisville, Kentucky
CYS	Cheyenne, Wyoming	DTW	Detroit, Michigan
LBF	North Platte, Nebraska	PHX	Phoenix, Arizona
BNA	Nashville, Tennessee	GTF	Great Falls, Montana
TOP	Topeka, Kansas		

Table 2.2. Comparative verification of early and final guidance and local PoP forecasts for 87 stations, 0000 GMT cycle.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24 h	Early/Final	.0837		47.79	
(1st period)	Local	.0772	8.08	52.04	10014
24-36 h	Early	.0985		33.27	
(2nd period)	Final	.1011		31.60	9872
	Local	.0969	1.41*(3.96)	34.41	
36-48 h	Early	.1054		34.40	
(3rd period)	Final	.1095		32.48	9872
	Local	.1029	2.33*(6.45)	36.28	

*This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.3. Same as Table 2.2 except for 26 stations in the Eastern Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24 h (1st period)	Early/Final	.0952		48.36	
	Local	.0922	3.18	50.00	2799
24-36 h (2nd period)	Early	.1024		44.93	
	Final	.1096		40.60	2765
	Local	.1027	-0.31*(6.19)	44.76	
36-48 h (3rd period)	Early	.1193		34.36	
	Final	.1278		29.41	2760
	Local	.1168	1.35*(8.58)	35.47	

*This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.4. Same as Table 2.2 except for 23 stations in the Southern Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24 h	Early/Final	.0730		62.98	
(1st period)	Local	.0655	10.16	66.74	2775
24-36 h	Early	.0853		31.72	
(2nd period)	Final	.0888		28.99	2732
	Local	.0878	-2.93*(1.21)	29.72	
36-48 h	Early	.0845		58.82	
(3rd period)	Final	.0938		54.32	2736
	Local	.0844	-0.06*(10.03)	58.79	

*This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.5. Same as Table 2.2 except for 22 stations in the Central Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24 h (1st period)	Early/Final	.0854		40.17	
	Local	.0790	7.40	44.60	2661
24-36 h (2nd period)	Early	.1064		30.38	
	Final	.1090		28.66	2622
	Local	.1033	2.96*(5.52)	32.44	
36-48 h (3rd period)	Early	.1128		20.70	
	Final	.1137		20.07	2622
	Local	.1124	0.36*(1.30)	20.98	

*This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.6. Same as Table 2.2 except for 16 stations in the Western Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24 h (1st period)	Early/Final	.0796		34.60	
	Local	.0688	13.58	43.48	1779
24-36 h (2nd period)	Early	.1010		21.61	
	Final	.0952		25.94	1753
	Local	.0923	8.59*(2.40)	28.34	
36-48 h (3rd period)	Early	.1049		16.84	
	Final	.0990		21.75	1754
	Local	.0938	10.58*(5.24)	25.63	

*This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 3.1. Sixty-two stations used for comparative verification of guidance and local precipitation type forecasts.

PWM	Portland, Maine	OKC	Oklahoma City, Oklahoma
BTV	Burlington, Vermont	ABQ	Albuquerque, New Mexico
BOS	Boston, Massachusetts	GTF	Great Falls, Montana
PVD	Providence, Rhode Island	DTW	Detroit, Michigan
BUF	Buffalo, New York	IND	Indianapolis, Indiana
SYR	Syracuse, New York	SDF	Louisville, Kentucky
ALB	Albany, New York	MKE	Milwaukee, Wisconsin
PIT	Pittsburgh, Pennsylvania	STL	St. Louis, Missouri
PHL	Philadelphia, Pennsylvania	MCI	Kansas City, Missouri
CLE	Cleveland, Ohio	TOP	Topeka, Kansas
CMH	Columbus, Ohio	DEN	Denver, Colorado
CRW	Charleston, West Virginia	CYS	Cheyenne, Wyoming
DCA	Washington, D.C.	BIS	Bismarck, North Dakota
ORF	Norfolk, Virginia	FAR	Fargo, North Dakota
RDU	Raleigh-Durham, North Carolina	RAP	Rapid City, South Dakota
CLT	Charlotte, North Carolina	FSD	Sioux Falls, South Dakota
CAE	Columbia, South Carolina	OMA	Omaha, Nebraska
ATL	Atlanta, Georgia	MSP	Minneapolis, Minnesota
MIA	Miami, Florida	DSM	Des Moines, Iowa
JAX	Jacksonville, Florida	FLG	Flagstaff, Arizona
BHM	Birmingham, Alabama	PHX	Phoenix, Arizona
MEM	Memphis, Tennessee	SLC	Salt Lake City, Utah
JAN	Jackson, Mississippi	LAS	Las Vegas, Nevada
MSY	New Orleans, Louisiana	RNO	Reno, Nevada
SHV	Shreveport, Louisiana	SAN	San Diego, California
IAH	Houston, Texas	LAX	Los Angeles, California
SAT	San Antonio, Texas	SFO	San Franicsco, California
DFW	Fort Worth, Texas	PDX	Portland, Oregon
ELP	El Paso, Texas	SEA	Seattle (Tacoma), Washington
LIT	Little Rock, Arkansas	GEG	Spokane, Washington
TUL	Tulsa, Oklahoma	BOI	Boise, Idaho

Table 3.2. Comparative verification of early PoPT guidance and local forecasts by NWS Region, 0000 GMT cycle. Only cases when local PoP was ≥ 30% are included.

Projection (h)	Region	Type of Forecast	Bias: Snow	Bias: Freezing Rain	Bias: Rain	Percent Correct	Skill Score	Number of Cases
18	Eastern	Early	.97	--	1.02	95	.88	236
		Local	.88	--	1.04	92	.78	
	Southern	Early	1.20	--	1.00	98	.83	110
		Local	1.00	--	1.00	95	.48	
	Central	Early	1.04	--	.95	91	.82	172
		Local	.96	--	1.01	84	.68	
	Western	Early	1.16	--	.95	93	.82	123
		Local	.90	--	1.02	93	.81	
	All Stations	Early	1.04	--	.99	94	.86	641
		Local	.92	--	1.02	90	.77	
30	Eastern	Early	1.07	--	.97	93	.83	247
		Local	1.10	--	.97	91	.79	
	Southern	Early	.60	--	1.04	97	.65	88
		Local	1.40	--	.98	94	.62	
	Central	Early	.94	--	1.08	92	.84	174
		Local	.94	--	1.08	88	.76	
	Western	Early	1.13	--	.93	89	.74	94
		Local	1.08	--	.96	90	.76	
	All Stations	Early	1.00	--	.93	93	.83	603
		Local	.99	--	.91	91	.79	
42	Eastern	Early	1.21	--	.90	91	.79	213
		Local	1.03	--	.99	92	.80	
	Southern	Early	.67	--	.99	95	.27	102
		Local	1.00	--	1.00	98	.66	
	Central	Early	1.03	--	.96	87	.75	142
		Local	.89	--	1.12	83	.67	
	Western	Early	1.13	--	.93	93	.82	94
		Local	.88	--	1.04	93	.80	
	All Stations	Early	1.10	--	.94	91	.79	551
		Local	.94	--	1.03	91	.78	

Table 3.3. Comparative verification of early PoPT guidance and local forecasts. Only those cases in which the locals and guidance differed, and the local PoP was ≥ 30%, were included.

Projection (h)	Type of Forecast	Percent Correct	Number of Cases
18	Early	74	53
	Local	26	
30	Early	58	62
	Local	39	
42	Early	49	51
	Local	49	

Table 3.4. Comparative verification of early PoPT guidance, final PoF guidance, and local forecasts, 0000 GMT cycle. Only cases when local PoP was ≥ 30% were included.

Projection (h)	Region	Type of Forecast	Bias Snow	Bias Rain	Percent Correct	Skill Score	Number of Cases
18	Eastern	Early	.97	1.01	96	.89	236
		Final	1.08	.97	94	.84	
		Local	.88	1.05	92	.80	
	Southern	Early	1.20	.99	99	.90	110
		Final	.60	1.02	98	.74	
		Local	1.00	1.00	96	.58	
	Central	Early	1.04	.95	91	.81	172
		Final	1.09	.90	88	.77	
		Local	.96	1.05	84	.67	
	Western	Early	1.16	.95	94	.86	123
		Final	1.16	.95	93	.82	
		Local	.90	1.03	94	.84	
	All Stations	Early	1.04	.98	95	.88	641
		Final	1.08	.96	93	.83	
		Local	.92	1.03	91	.78	
30	Eastern	Early	1.07	.97	94	.85	247
		Final	1.04	.98	93	.83	
		Local	1.10	.96	92	.79	
	Southern	Early	.60	1.02	98	.74	88
		Final	.40	1.04	97	.56	
		Local	1.40	.98	96	.64	
	Central	Early	.94	1.08	93	.86	174
		Final	.83	1.21	91	.82	
		Local	.94	1.08	90	.79	
	Western	Early	1.13	.96	90	.76	94
		Final	1.21	.93	90	.76	
		Local	1.08	.97	92	.78	
	All Stations	Early	1.00	1.00	94	.86	603
		Final	.94	1.03	93	.83	
		Local	1.03	.99	92	.81	
42	Eastern	Early	1.21	.92	93	.82	213
		Final	1.17	.94	92	.80	
		Local	1.03	.99	93	.81	
	Southern	Early	.67	1.01	97	.39	102
		Final	1.00	1.00	98	.66	
		Local	1.00	1.00	98	.66	
	Central	Early	1.00	1.00	90	.80	140
		Final	.97	1.03	89	.77	
		Local	.86	1.15	84	.69	
	Western	Early	1.14	.96	95	.86	92
		Final	1.14	.96	92	.80	
		Local	.86	1.04	92	.78	
	All Stations	Early	1.09	.96	93	.84	547
		Final	1.07	.97	92	.81	
		Local	.93	1.03	91	.79	

Table 4.1. Ninety-four stations used for comparative verification of guidance and local sky cover, surface wind, ceiling, and visibility forecasts.

PWM	Portland, Maine	GTF	Great Falls, Montana
BTV	Burlington, Vermont	TCC	Tucumcari, New Mexico
CON	Concord, New Hampshire	APN	Alpena, Michigan
BOS	Boston, Massachusetts	DTW	Detroit, Michigan
PVD	Providence, Rhode Island	SBN	South Bend, Indiana
BUF	Buffalo, New York	IND	Indianapolis, Indiana
SYR	Syracuse, New York	LEX	Lexington, Kentucky
ALB	Albany, New York	SDF	Louisville, Kentucky
JFK	New York (Kennedy), New York	MSN	Madison, Wisconsin
EWR	Newark, New Jersey	MKE	Milwaukee, Wisconsin
ERI	Erie, Pennsylvania	ORD	Chicago (O'Hare), Illinois
AVP	Scranton, Pennsylvania	SPI	Springfield, Illinois
PIT	Pittsburgh, Pennsylvania	STL	St. Louis, Missouri
PHL	Philadelphia, Pennsylvania	MCI	Kansas City, Missouri
CLE	Cleveland, Ohio	TOP	Topeka, Kansas
CMH	Columbus, Ohio	DDC	Dodge City, Kansas
HTS	Huntington, West Virginia	DEN	Denver, Colorado
CRW	Charleston, West Virginia	GJT	Grand Junction, Colorado
DCA	Washington, D.C.	SHR	Sheridan, Wyoming
ORF	Norfolk, Virginia	CYS	Cheyenne, Wyoming
RDU	Raleigh-Durham, North Carolina	BIS	Bismarck, North Dakota
CLT	Charlotte, North Carolina	FAR	Fargo, North Dakota
CHS	Charleston, South Carolina	RAP	Rapid City, South Dakota
CAE	Columbia, South Carolina	FSD	Sioux Falls, South Dakota
ATL	Atlanta, Georgia	BFF	Scottsbluff, Nebraska
SAV	Savannah, Georgia	OMA	Omaha, Nebraska
MIA	Miami, Florida	MSP	Minneapolis, Minnesota
JAX	Jacksonville, Florida	DSM	Des Moines, Iowa
BHM	Birmingham, Alabama	BRL	Burlington, Iowa.
MOB	Mobile, Alabama	INL	International Falls, Minnesota
TYS	Knoxville, Tennessee	FLG	Flagstaff, Arizona
MEM	Memphis, Tennessee	PHX	Phoenix, Arizona
MEI	Meridian, Mississippi	CDC	Cedar City, Utah
JAN	Jackson, Mississippi	SLC	Salt Lake City, Utah
MSY	New Orleans, Louisiana	LAS	Las Vegas, Nevada
SHV	Shreveport, Louisiana	RNO	Reno, Nevada
IAH	Houston, Texas	SAN	San Diego, California
SAT	San Antonio, Texas	LAX	Los Angeles, California
DFW	Dallas-Fort Worth, Texas	FAT	Fresno, California
ABI	Abilene, Texas	SFO	San Francisco, California
LBB	Lubbock, Texas	PDX	Portland, Oregon
ELP	El Paso, Texas	PDT	Pendleton, Oregon
LIT	Little Rock, Arkansas	SEA	Seattle (Takoma), Washington
FSM	Fort Smith, Arkansas	GEG	Spokane, Washington
TUL	Tulsa, Oklahoma	BOI	Boise, Idaho
OKC	Oklahoma City, Oklahoma	PIH	Pocatello, Idaho
ABQ	Albuquerque, New Mexico	MSO	Missoula, Montana

Table 4.2. Comparative verification of early guidance and local surface wind forecasts for 94 stations, 0000 GMT.

		Direction		Speed													
								Contingency Table									
										Bias by Category							
Fcst. Proj. (h)	Type of Fcst.	Mean Abs. Error (Deg)	No. of Cases	Mean Abs. Error (Kts)	Mean Fcst. (Kts)	Mean Obs. (Kts)	No. of Cases	Skill Score	Percent Fcst. Correct	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	26	7158	3.2	13.0	12.4	7195	.35	55	1.08	0.95	0.94	0.97	0.91	0.97	0.29	13458
	Local	30		3.4	13.4			.30	51	0.77 (5127)	1.21 (4728)	1.11 (2550)	1.03 (811)	0.53 (202)	1.09 (33)	0.57 (7)	
30	Early	30	4435	3.6	11.9	10.7	4508	.34	63	1.01	1.01	1.00	0.85	0.63	0.32	0.00	13394
	Local	35		3.9	12.2			.27	57	0.85 (7950)	1.33 (3693)	1.07 (1313)	0.87 (342)	0.66 (70)	0.63 (19)	0.14 (7)	
42	Early	35	6845	3.8	13.0	11.9	6913	.26	49	1.05	0.98	0.97	0.95	0.87	1.58	0.50	13212
	Local	41		4.0	12.7			.21	46	0.81 (5027)	1.29 (4680)	0.99 (2489)	0.66 (785)	0.38 (192)	0.48 (31)	0.38 (8)	

Table 4.3. Contingency tables for early guidance and local surface wind speed forecasts for 94 stations, 0000 GMT cycle.

18-h Forecasts

GUIDANCE

		1	2	3	4	5	6	7	T
	1	3693	1206	208	20	0	0	0	5127
	2	1622	2274	750	71	8	3	0	4728
	3	205	934	1058	314	37	2	0	2550
OBS	4	17	96	328	287	75	6	2	811
	5	1	9	47	81	50	14	0	202
	6	0	3	2	10	11	7	0	33
	7	0	1	1	2	3	0	0	7
	T	5538	4523	2394	785	184	32	2	13458

LOCAL

		1	2	3	4	5	6	7	T
	1	2814	1953	326	32	2	0	0	5127
	2	993	2666	923	138	6	2	0	4728
	3	128	937	1140	317	18	10	0	2550
OBS	4	15	132	362	255	35	12	2	811
	5	1	11	63	84	34	8	1	202
	6	0	2	6	12	11	1	1	33
	7	0	0	0	3	1	3	0	7
	T	3951	5701	2820	839	107	36	4	13458

30-h Forecasts

GUIDANCE

		1	2	3	4	5	6	7	T
	1	6287	1445	196	21	0	1	0	7950
	2	1516	1611	499	62	5	0	0	3693
	3	178	588	440	102	5	0	0	1313
OBS	4	21	76	143	78	22	2	0	342
	5	1	15	24	21	8	1	0	70
	6	0	3	4	7	4	1	0	19
	7	1	1	3	1	0	1	0	7
	T	8004	3739	1309	292	44	6	0	13394

LOCAL

		1	2	3	4	5	6	7	T
	1	5327	2279	299	39	4	2	0	7950
	2	1243	1832	540	69	8	1	0	3693
	3	146	645	413	95	12	2	0	1313
OBS	4	15	117	123	69	14	4	0	342
	5	3	19	24	17	5	2	0	70
	6	0	4	4	8	2	1	0	19
	7	0	1	4	0	1	0	1	7
	T	6734	4897	1407	297	46	12	1	13394

42-h Forecasts

GUIDANCE

		1	2	3	4	5	6	7	T
	1	3267	1368	344	48	0	0	0	5027
	2	1653	2068	787	151	19	2	0	4680
	3	318	925	886	306	43	10	1	2489
OBS	4	35	176	321	174	60	18	1	785
	5	3	28	56	55	35	13	2	192
	6	0	2	7	9	8	5	0	31
	7	0	1	1	3	2	1	0	8
	T	5276	4568	2402	746	167	49	4	13212

LOCAL

		1	2	3	4	5	6	7	T
	1	2538	2036	404	46	3	0	0	5027
	2	1168	2559	841	103	7	2	0	4680
	3	303	1137	825	193	26	5	0	2489
OBS	4	53	277	304	131	17	3	0	785
	5	10	37	85	40	13	4	3	192
	6	0	4	15	8	3	1	0	31
	7	2	1	1	1	3	0	0	8
	T	4074	6051	2475	522	72	15	3	13212

Table 4.4. Same as Table 4.2 except for 24 stations in the Eastern Region.

		Direction		Speed													
								Contingency Table									
										Bias by Category							
Fcst. Proj. (h)	Type of Fcst.	Mean Abs. Error (Deg)	No. of Cases	Mean Abs. Error (Kts)	Mean Fcst. (Kts)	Mean Obs. (Kts)	No. of Cases	Skill Score	Percent Fcst. Correct	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	25	1851	2.9	13.0	12.6	1853	0.35	54	1.10	0.96	0.92	1.00	0.83	1.29	*	3121
	Local	28		3.3	13.7			0.28	49	0.75 (1027)	1.13 (1157)	1.16 (668)	1.04 (204)	0.64 (58)	2.43 (7)	* (0)	
30	Early	28	1132	3.2	11.6	11.1	1150	0.37	64	1.04	1.04	0.78	0.80	0.67	0.25	0.00	3101
	Local	33		3.8	12.8			0.31	57	0.81 (1752)	1.30 (875)	1.17 (364)	1.13 (88)	1.40 (15)	1.00 (4)	0.00 (3)	
42	Early	31	1789	3.5	12.9	12.1	1802	0.27	49	1.08	0.97	0.95	0.94	0.69	3.33	**	3087
	Local	38		3.8	13.1			0.21	45	0.73 (1032)	1.22 (1159)	1.11 (654)	0.88 (182)	0.57 (54)	1.00 (6)	** (0)	

* This category was neither forecast nor observed.
** This category was forecast once but never observed.

Table 4.5. Same as Table 4.2 except for 24 stations in the Southern Region.

Fcst. Proj. (h)	Type of Fcst.	Direction		Speed													
								Contingency Table									
										Bias by Category							
		Mean Abs. Error (Deg)	No. of Cases	Mean Abs. Error (Kts)	Mean Fcst. (Kts)	Mean Obs. (Kts)	No. of Cases	Skill Score	Percent Fcst. Correct	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	27	2071	3.0	12.5	11.6	2083	0.32	54	1.10	0.90	1.01	1.21	1.02	1.25	*	3629
	Local	30		3.2	12.8			0.28	52	0.68 (1254)	1.21 (1525)	1.11 (652)	1.25 (154)	0.50 (40)	0.00 (4)	* (0)	
30	Early	32	1094	3.5	11.7	10.2	1112	0.37	66	0.98	1.01	1.12	1.06	0.36	0.00	*	3604
	Local	37		3.8	11.6			0.27	59	0.86 (2266)	1.38 (972)	0.94 (285)	0.70 (69)	0.27 (11)	1.00 (1)	* (0)	
42	Early	37	1964	3.7	12.9	11.2	1978	0.22	47	1.05	0.88	1.06	1.34	1.53	2.67	*	3513
	Local	43		3.7	12.3			0.17	45	0.76 (1214)	1.26 (1476)	0.99 (629)	0.68 (155)	0.31 (36)	0.00 (3)	* (0)	

* This category was neither forecast nor observed.

Table 4.6. Same as Table 4.2 except for 28 stations in the Central Region.

Fcst. Proj. (h)	Type of Fcst.	Direction: Mean Abs. Error (Deg)	Direction: No. of Cases	Speed: Mean Abs. Error (Kts)	Speed: Mean Fcst. (Kts)	Speed: Mean Obs. (Kts)	Speed: No. of Cases	Contingency Table: Skill Score	Contingency Table: Percent Fcst. Correct	Bias by Category: 1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	23	2469	3.1	13.3	13.1	2477	0.34	52	1.22	0.93	0.87	0.90	0.97	0.88	0.67	4146
	Local	28		3.4	13.7			0.27	48	0.77 (1221)	1.18 (1531)	1.06 (958)	0.94 (342)	0.53 (74)	0.82 (17)	0.67 (3)	
30	Early	27	1618	3.6	12.1	11.2	1632	0.31	58	1.05	0.94	1.02	0.89	0.79	0.31	0.00	4151
	Local	33		3.9	12.4			0.24	52	0.81 (2177)	1.31 (1314)	1.12 (480)	0.82 (131)	0.58 (33)	0.54 (13)	0.33 (3)	
42	Early	32	2358	3.8	13.3	12.7	2375	0.24	46	1.24	0.93	0.89	0.85	0.83	1.12	1.00	4106
	Local	38		4.0	12.9			0.17	42	0.85 (1192)	1.28 (1536)	0.94 (942)	0.60 (339)	0.32 (77)	0.35 (17)	0.67 (3)	

Table 4.7. Same as Table 4.2 except for 18 stations in the Western Region.

		Direction		Speed														
										Contingency Table								
										Bias by Category								
Fcst. Proj. (h)	Type of Fcst.	Mean Abs. Error (Deg)	No. of Cases	Mean Abs. Error (Kts)	Mean Fcst. (Kts)	Mean Obs. (Kts)	No. of Cases	Skill Score	Percent Fcst. Correct	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	38	767	4.4	13.1	11.8	782	0.31	61	0.95	1.21	1.07	0.77	0.77	0.60	0.00	2562
	Local	38		4.4	13.6			0.29	59	0.86 (1625)	1.43 (515)	1.12 (272)	1.02 (111)	0.37 (30)	1.00 (5)	0.50 (4)	
30	Early	40	591	4.3	11.7	9.8	614	0.27	64	0.95	1.15	1.18	0.61	0.36	1.00	0.00	2538
	Local	43		4.4	11.9			0.25	63	0.92 (1755)	1.33 (532)	0.97 (184)	0.80 (54)	0.27 (11)	0.00 (1)	0.00 (1)	
42	Early	46	734	4.9	12.5	10.7	758	0.23	56	0.89	1.43	1.06	0.72	0.44	0.40	0.00	2506
	Local	55		5.0	12.2			0.20	54	0.87 (1589)	1.59 (509)	0.93 (264)	0.50 (109)	0.20 (25)	0.60 (5)	0.00 (5)	

Table 4.8. Distribution of absolute errors associated with early guidance and local forecasts of surface wind direction for 94 stations, 0000 GMT cycle.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0–30°	40–60°	70–90°	100–120°	130–150°	160–180°
18	Early	77.6	14.2	3.9	2.0	1.4	0.9
	Local	72.8	16.4	5.2	2.8	1.8	1.0
30	Early	71.8	16.7	5.4	3.2	1.5	1.5
	Local	65.3	19.4	7.4	3.8	2.3	1.8
42	Early	66.5	18.0	7.2	3.9	2.3	2.1
	Local	58.2	21.8	9.1	5.0	3.5	2.5

Table 4.9. Same as Table 4.8 except for 24 stations in the Eastern Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0–30°	40–60°	70–90°	100–120°	130–150°	160–180°
18	Early	77.5	15.5	4.0	1.7	1.0	0.3
	Local	74.4	17.3	4.1	2.3	1.5	0.4
30	Early	72.7	18.5	4.8	2.2	1.1	0.7
	Local	65.5	22.1	6.9	3.4	1.3	0.9
42	Early	70.4	16.3	6.7	3.3	1.8	1.5
	Local	62.6	20.7	7.9	4.1	2.7	1.9

Table 4.10. Same as Table 4.8 except for 24 stations in the Southern Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0–30°	40–60°	70–90°	100–120°	130–150°	160–180°
18	Early	76.8	15.1	3.9	1.9	1.3	1.0
	Local	71.5	17.2	5.9	2.9	1.2	1.2
30	Early	69.7	17.6	5.6	3.6	1.5	2.0
	Local	64.2	19.7	7.5	4.0	2.0	2.6
42	Early	63.0	20.9	7.7	3.9	2.3	2.2
	Local	54.6	23.8	10.2	5.8	3.3	2.4

Table 4.11. Same as Table 4.8 except for 29 stations in the Central Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	Early	82.5	11.2	3.0	1.5	1.1	0.6
	Local	75.3	14.8	4.9	2.5	1.7	0.8
30	Early	76.1	14.2	4.8	3.2	1.0	0.8
	Local	69.1	17.2	6.6	3.3	2.3	1.4
42	Early	69.6	17.0	6.8	3.2	1.9	1.6
	Local	60.9	21.5	8.4	4.2	3.1	1.9

Table 4.12. Same as Table 4.8 except for 18 stations in the Western Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0–30°	40–60°	70–90°	100–120°	130–150°	160–180°
18	Early	64.3	18.4	6.3	4.3	3.9	2.9
	Local	64.5	17.2	7.3	4.2	4.0	2.7
30	Early	61.9	18.3	8.0	4.2	3.6	4.1
	Local	56.7	19.8	10.5	5.6	4.6	2.9
42	Early	56.9	17.3	8.6	7.5	4.8	4.9
	Local	48.2	19.6	10.8	7.9	7.2	6.3

Table 5.1 Definitions of the categories used for guidance forecasts of cloud amount.

Category	Cloud Amount (Opaque Sky Cover in tenths)
1	0-1
2	2-5
3	6-9
4	10

Table 5.2. Comparative verification of early guidance and local forecasts of four categories of cloud amount (clear, scattered, broken, and overcast) for 94 stations, 0000 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
	Early	1.08	0.75	1.06	1.06	51.7	.342	
18	Local	0.69	1.41	1.36	0.80	50.6	.344	13229
	No. Obs.	3757	2795	2415	4262			
	Early	1.11	0.83	0.79	1.02	56.5	.356	
30	Local	0.63	1.95	1.98	0.70	45.9	.279	12929
	No. Obs.	5174	1905	1421	4429			
	Early	1.25	0.81	0.89	0.97	46.5	.270	
42	Local	0.56	1.79	1.46	0.60	39.3	.205	12963
	No. Obs.	3622	2733	2386	4222			

Table 5.3. Same as Table 5.2 except for 24 stations in the Eastern Region.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
	Early	1.08	0.63	1.02	1.13	52.4	.337	
18	Local	0.53	1.54	1.47	0.76	48.6	.313	3063
	No. Obs.	710	600	597	1156			
	Early	1.16	0.66	1.11	0.95	57.5	.365	
30	Local	0.65	1.91	2.22	0.71	48.1	.297	3014
	No. Obs.	1005	385	316	1308			
	Early	1.24	0.71	1.08	0.97	45.3	.250	
42	Local	0.44	1.82	1.51	0.64	40.2	.210	3002
	No. Obs.	690	596	596	1120			

Table 5.4. Same as Table 5.2 except for 24 stations in the Southern Region.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
	Early	1.08	0.84	1.00	1.02	53.1	.355	
18	Local	0.76	1.52	1.30	0.69	50.7	.341	3537
	No. Obs.	1257	777	588	915			
	Early	1.09	1.04	0.39	1.04	61.0	.385	
30	Local	0.70	2.14	1.69	0.66	49.2	.294	3506
	No. Obs.	1747	509	351	899			
	Early	1.24	0.88	0.64	1.04	50.1	.303	
42	Local	0.64	1.96	1.34	0.50	39.7	.204	3466
	No. Obs.	1233	746	567	920			

Table 5.5. Same as Table 5.2 except for 28 stations in the Central Region.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
	Early	0.96	0.68	1.20	1.13	51.4	.333	
18	Local	0.60	1.35	1.43	0.86	50.7	.340	4137
	No. Obs.	1050	901	730	1456			
	Early	1.01	0.63	1.01	1.13	54.9	.334	
30	Local	0.52	2.03	2.17	0.74	43.5	.252	3939
	No. Obs.	1457	593	407	1482			
	Early	1.12	0.81	0.99	1.03	46.0	.259	
42	Local	0.46	1.74	1.52	0.65	37.7	.176	4016
	No. Obs.	971	874	717	1454			

Table 5.6. Same as Table 5.2 except for 18 stations in the Western Region.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
	Early	1.25	0.89	0.96	0.85	49.4	.314	
18	Local	0.84	1.22	1.18	0.89	52.8	.370	2492
	No. Obs.	740	517	500	735			
	Early	1.22	1.01	0.62	0.88	51.2	.296	
30	Local	0.67	1.65	1.84	0.68	42.6	.239	2470
	No. Obs.	965	418	347	740			
	Early	1.50	0.80	0.79	0.79	43.6	.233	
42	Local	0.70	1.58	1.45	0.58	40.3	.216	2479
	No. Obs.	728	517	506	728			

Table 6.1. Definitions of the categories used for guidance forecasts of ceiling and visibility.

Category	Ceiling (ft)	Visibility (mi)
1	<200	<1/2
2	200-400	1/2-7/8
3	500-900	1-2 1/2
4	1000-2900	3-4
5	3000-7500	5-6
6	>7500	>6

Table 6.2 Comparative verification of early guidance, persistence, and local ceiling forecasts for 94 stations, 0000 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category						Percent Correct	Skill Score
		1	2	3	4	5	6		
12	Early	0.77	0.87	1.01	1.19	1.09	0.96	63.3	.377
	Local	0.56	0.87	0.86	1.17	1.11	0.98	74.5	.562
	Persistence	0.89	0.88	0.91	0.91	1.02	1.03	76.0	.577
	No. Obs.	261	534	724	1728	1809	8185		
15	Local	0.38	0.57	0.69	1.20	1.23	0.98	67.3	.442
	Persistence	1.38	0.82	0.86	0.86	1.07	1.04	66.6	.417
	No. Obs.	179	613	874	2088	1878	8834		
18	Early	0.61	0.88	0.94	1.13	1.04	0.97	63.8	.357
	Persistence	3.62	1.35	0.88	0.80	1.08	1.01	63.5	.299
	No. Obs.	66	357	785	2042	1759	8633		
21	Local	0.18	0.42	0.60	1.18	1.19	0.97	66.8	.389
	Persistence	4.82	1.93	1.14	0.89	0.96	0.98	60.7	.284
	No. Obs.	50	267	653	2010	2090	9375		
24	Early	0.23	0.75	0.91	1.19	1.01	0.99	66.2	.350
	Persistence	3.29	1.69	1.17	1.08	0.92	0.95	58.6	.229
	No. Obs.	73	286	585	1519	2068	9115		
36	Early	0.39	0.77	0.84	1.11	0.99	1.03	59.2	.285
	Persistence	0.90	0.88	0.88	0.90	1.03	1.04	51.8	.153
	No. Obs.	266	547	780	1824	1854	8370		
48	Early	0.15	0.90	0.83	1.03	0.82	1.06	62.9	.256
	Persistence	3.53	1.68	1.18	1.06	0.91	0.96	57.1	.092
	No. Obs.	68	288	583	1544	2100	9061		

Table 6.3. Same as Table 6.2 except for visibility.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Skill Score
12	Early	1.00	1.13	0.87	1.22	0.97	0.99	72.1	.296
	Local	0.61	1.09	0.81	1.51	1.19	0.97	77.4	.448
	Persistence	0.78	0.85	0.81	0.83	0.88	1.05	81.4	.490
	No. Obs.	299	198	729	797	964	10089		
15	Local	0.40	0.60	0.45	1.18	0.93	1.07	72.5	.308
	Persistence	0.95	0.70	0.65	0.79	0.76	1.09	73.0	.307
	No. Obs.	262	268	1043	931	1211	10658		
18	Early	0.82	1.09	0.83	1.21	1.00	1.00	74.1	.247
	Persistence	2.31	1.19	0.82	1.00	0.89	1.01	74.5	.253
	No. Obs.	105	150	752	692	976	10916		
21	Local	0.11	0.45	0.43	1.26	1.00	1.03	79.9	.265
	Persistence	3.88	1.35	0.94	1.26	1.08	0.97	74.2	.190
	No. Obs.	65	136	711	591	869	11969		
24	Early	0.65	0.96	0.80	1.16	0.86	1.01	80.2	.271
	Persistence	3.08	1.44	1.07	1.18	1.16	0.96	74.5	.178
	No. Obs.	79	124	577	589	751	11472		
36	Early	0.37	0.67	0.86	1.09	0.91	1.04	69.8	.053
	Persistence	0.81	0.87	0.81	0.82	.087	1.05	68.1	.126
	No. Obs.	300	206	761	845	1006	10472		
48	Early	0.13	0.99	0.98	0.96	0.77	1.02	78.9	.201
	Persistence	3.12	1.38	1.10	1.15	1.18	0.96	71.5	.080
	No. Obs.	78	130	564	605	704	13591		

Table 6.4. Same as Table 6.2 except for 1200 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category						Percent Correct	Skill Score
		1	2	3	4	5	6		
12	Early	0.46	0.95	1.02	1.18	1.03	0.97	67.9	.391
	Local	0.24	0.73	0.80	1.42	1.01	0.96	77.1	.569
	Persistence	0.70	0.83	1.04	1.21	0.96	0.98	77.1	.563
	No. Obs.	63	282	583	1475	2000	8868		
15	Local	0.16	0.70	0.83	1.42	0.93	0.98	71.5	.470
	Persistence	0.39	0.71	1.04	1.18	0.98	0.99	69.8	.434
	No. Obs.	135	364	642	1657	2099	9352		
18	Early	0.64	0.77	1.08	1.30	1.06	0.95	64.5	.358
	Persistence	0.27	0.59	0.97	1.17	1.01	1.00	64.8	.338
	No. Obs.	171	402	641	1561	1952	8960		
21	Local	0.19	0.70	0.94	1.45	0.96	0.96	64.3	.377
	Persistence	0.24	0.49	0.91	1.08	1.05	1.03	61.3	.295
	No. Obs.	219	532	727	1815	1946	8944		
24	Early	0.67	0.91	1.12	1.19	1.06	0.95	60.0	.326
	Persistence	0.18	0.43	0.80	1.01	1.06	1.07	57.9	.243
	No. Obs.	261	549	776	1820	1855	8423		
36	Early	0.28	1.36	0.89	1.05	0.89	1.02	64.2	.298
	Persistence	0.65	0.82	1.10	1.20	0.95	0.98	54.8	.136
	No. Obs.	71	289	568	1529	2087	9143		
48	Early	0.44	0.87	0.97	0.90	1.10	1.03	57.6	.255
	Persistence	0.18	0.43	0.80	1.01	1.07	1.06	49.8	.096
	No. Obs.	261	553	775	1818	1849	8428		

Table 6.5. Same as Table 6.3 except for 1200 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Skill Score
12	Early	0.35	0.89	0.99	0.96	0.91	1.01	81.7	.314
	Local	0.40	0.78	0.73	1.45	1.35	0.97	84.4	.469
	Persistence	0.69	1.04	1.17	0.92	1.13	0.99	86.4	.521
	No. Obs.	68	114	545	528	722	11213		
15	Local	0.33	0.98	0.97	1.65	1.35	0.95	81.0	.372
	Persistence	0.47	1.12	1.47	0.89	1.18	0.98	82.4	.378
	No. Obs.	113	121	490	636	762	12138		
18	Early	0.78	0.80	1.02	1.11	0.92	1.00	78.6	.278
	Persistence	0.29	0.98	1.20	0.83	1.09	1.00	79.1	.291
	No. Obs.	174	126	549	659	778	11390		
21	Local	0.31	1.08	1.11	1.90	1.21	0.93	73.0	.280
	Persistence	0.21	0.79	1.11	0.76	1.02	1.03	75.7	.232
	No. Obs.	245	177	646	742	880	11524		
24	Early	0.77	1.08	1.30	1.02	0.89	0.99	70.4	.261
	Persistence	0.17	0.60	0.86	0.64	0.82	1.09	71.7	.184
	No. Obs.	306	207	767	857	1037	10502		
36	Early	0.30	0.87	1.13	1.00	0.83	1.01	78.6	.219
	Persistence	0.65	1.01	1.16	0.90	1.12	0.99	74.7	.118
	No. Obs.	79	123	572	608	755	11540		
48	Early	0.41	1.00	0.98	0.89	0.88	1.04	69.5	.189
	Persistence	0.17	0.58	0.85	0.63	0.83	1.38	67.9	.077
	No. Obs.	301	213	779	868	1027	13676		

Table 6.6. Comparative verification for early guidance, persistence, and local ceiling forecasts for 94 stations, 0000 GMT cycle. Scores are computed from two-category contingency tables.

Projection (h)	Type of Forcast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
12	Early		0.84	93.3	.358	.245
	Local	.060	0.77	95.8	.587	.437
	Persistence		0.88	95.9	.617	.469
15	Local		0.53	95.0	.374	.248
	Persistence	.055	0.95	94.3	.433	.301
18	Early		0.84	95.5	.193	.121
	Persistence	.031	1.17	94.3	.299	.195
21	Local		0.38	97.5	.163	.095
	Persistence	.022	2.38	94.0	.172	.110
24	Early		0.65	96.5	.179	.109
	Persistence	.026	2.01	93.5	.151	.100
36	Early		0.64	92.3	.175	.120
	Persistence	.060	0.89	90.9	.144	.106
48	Early		0.76	96.2	.147	.091
	Persistence	.026	2.03	92.8	.056	.047

Table 6.7. Same as Table 6.6 except for visibility.

Projection (h)	Type of Forcast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
12	Early	.038	1.05	94.2	.221	.144
	Local		0.80	96.9	.524	.370
	Persistence		0.81	96.9	.529	.375
15	Local	.037	0.50	96.2	.292	.183
	Persistence		0.82	95.6	.327	.211
18	Early	.019	0.98	97.0	.187	.112
	Persistence		1.65	96.0	.185	.114
21	Local	.014	0.34	98.3	.090	.051
	Persistence		2.17	96.1	.105	.065
24	Early	.015	0.84	97.6	.128	.075
	Persistence		2.08	96.0	.107	.067
36	Early	.037	0.50	94.8	.053	.040
	Persistence		0.74	94.2	.126	.084
48	Early	.015	0.67	97.7	.104	.061
	Persistence		2.03	95.7	.044	.033

Table 6.8. Same as Table 6.6 except for 1200 GMT cycle.

Projection (h)	Type of Forcast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
12	Early		0.86	96.3	.227	.140
	Local	.026	0.64	97.7	.455	.303
	Persistence		0.81	97.8	.528	.369
15	Local		0.56	96.5	.344	.220
	Persistence	.035	0.62	96.6	.381	.248
18	Early		0.73	94.5	.222	.143
	Persistence	.042	0.49	95.4	.248	.155
21	Local		0.55	94.1	.253	.164
	Persistence	.053	0.42	94.0	.175	.112
24	Early		0.84	92.1	.233	.159
	Persistence	.059	0.35	93.1	.110	.074
36	Early		1.14	95.6	.203	.127
	Persistence	.026	0.79	95.7	.059	.042
48	Early		0.73	92.0	.179	.124
	Persistence	.059	0.35	92.5	.036	.034

Table 6.9. Same as Table 6.7 except for 1200 GMT cycle.

Projection (h)	Type of Forcast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
12	Early	.016	0.69	98.1	.153	.089
	Local		0.64	98.5	.315	.192
	Persistence		0.92	98.5	.412	.265
15	Local	.016	0.66	98.1	.278	.168
	Persistence		0.81	97.8	.259	.156
18	Early	.022	0.79	96.7	.151	.091
	Persistence		0.58	97.1	.142	.084
21	Local	.030	0.63	96.1	.170	.104
	Persistence		0.45	96.2	.094	.059
24	Early	.038	0.89	94.2	.157	.103
	Persistence		0.34	95.3	.055	.038
36	Early	.015	0.65	97.8	.098	.057
	Persistence		0.87	97.3	.018	.016
48	Early	.038	0.34	94.5	.081	.057
	Persistence		0.65	95.1	.001	.010

Table 7.1. Comparative verification of early and final guidance and local max/min temperature forecasts for 87 stations, 0000 GMT cycle.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (^oF)	Mean Absolute Error (^oF)	Number(%) of Absolute Errors $\geq 10^o$	Number of Cases
	Early	-0.1	3.5	455 (4.3)	
24 (Max)	Final	-1.1	3.7	539 (5.1)	10641
	Local	-0.4	3.3	394 (3.7)	
	Early	-0.7	4.2	796 (7.5)	
36 (Min)	Final	-0.4	4.2	787 (7.5)	10554
	Local	0.5	4.0	781 (7.4)	
	Early	-1.0	4.6	1122 (10.6)	
48 (Max)	Final	-1.5	4.7	1211 (11.5)	10536
	Local	-1.0	4.3	970 (9.2)	
	Early	-1.3	5.3	1692 (16.1)	
60 (Min)	Final	-0.1	5.1	1423 (13.5)	10530
	Local	0.2	4.9	1309 (12.4)	

Table 7.2. Same as Table 7.1 except for 26 stations in the Eastern Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors $\geq$ 10°	Number of Cases
24 (Max)	Early	0.2	3.4	116 (3.8)	3054
	Final	-0.6	3.4	123 (4.0)	
	Local	-0.4	3.4	124 (4.1)	
36 (Min)	Early	-0.9	3.9	161 (5.3)	3030
	Final	-0.7	4.0	180 (5.9)	
	Local	0.6	3.9	193 (6.4)	
48 (Max)	Early	-1.2	4.5	311 (10.3)	3028
	Final	-1.2	4.5	298 (9.8)	
	Local	-1.5	4.5	287 (9.5)	
60 (Min)	Early	-1.4	5.1	412 (13.6)	3030
	Final	-0.6	5.0	378 (12.5)	
	Local	0.2	4.7	344 (11.4)	

Table 7.3. Same as Table 7.1 except for 23 stations in the Southern Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number(%) of Absolute Errors ≥ 10°	Number of Cases
24 (Max)	Early	-0.3	3.5	128 (4.4)	2877
	Final	-1.2	3.7	149 (5.2)	
	Local	-0.3	3.2	105 (3.6)	
36 (Min)	Early	-0.5	4.1	205 (7.2)	2853
	Final	0.1	4.2	214 (7.5)	
	Local	0.6	4.0	187 (6.6)	
48 (Max)	Early	-1.4	4.7	327 (11.5)	2851
	Final	-1.9	4.7	356 (12.5)	
	Local	-0.7	4.2	274 (9.6)	
60 (Min)	Early	-1.2	5.1	399 (14.0)	2845
	Final	0.7	5.0	377 (13.2)	
	Local	0.7	4.8	322 (11.3)	

Table 7.4. Same as Table 7.1 except for 22 stations in the Central Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (^oF)	Mean Absolute Error (^oF)	Number(%) of Absolute Errors $\geq 10^o$	Number of Cases
24 (Max)	Early	-0.4	3.7	137 (4.8)	2843
	Final	-1.5	4.1	204 (7.2)	
	Local	-0.7	3.5	108 (3.8)	
36 (Min)	Early	-0.6	4.6	283 (10.0)	2820
	Final	-0.5	4.5	272 (9.6)	
	Local	0.6	4.4	269 (9.5)	
48 (Max)	Early	-0.3	4.7	292 (10.4)	2801
	Final	-1.5	5.1	399 (14.2)	
	Local	-1.0	4.5	273 (9.7)	
60 (Min)	Early	-1.7	6.1	613 (21.9)	2801
	Final	0.2	5.4	448 (16.0)	
	Local	-0.0	5.4	450 (16.1)	

Table 7.5. Same as Table 7.1 except for 16 stations in the Western Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number(%) of Absolute Errors $\geq 10^{\circ}$	Number of Cases
24 (Max)	Early	-0.0	3.2	74 (4.0)	1867
	Final	-1.3	3.4	63 (3.4)	
	Local	-0.2	3.1	57 (3.1)	
36 (Min)	Early	-0.8	4.0	147 (7.9)	1851
	Final	-0.7	3.9	121 (6.5)	
	Local	0.1	3.9	132 (7.1)	
48 (Max)	Early	-0.9	4.4	192 (10.3)	1856
	Final	-1.7	4.4	158 (8.5)	
	Local	-0.7	4.1	136 (7.3)	
60 (Min)	Early	-1.1	5.2	268 (14.5)	1854
	Final	-0.9	4.8	220 (11.9)	
	Local	-0.1	4.7	193 (10.4)	

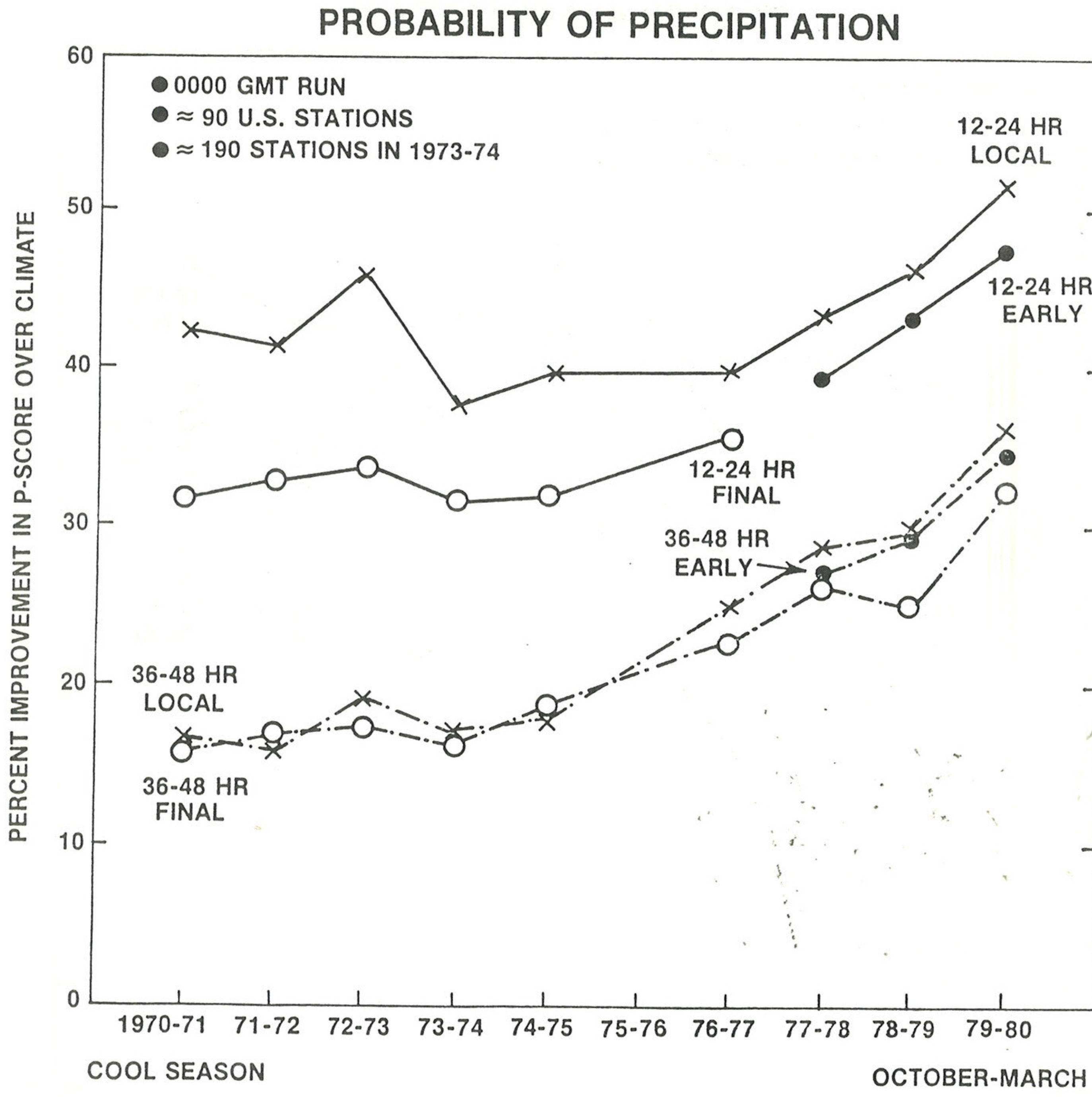

Fig. 2.1. Percent improvement over climate in the Brier score (P-score) of the local and guidance PoP forecasts for the cool season. Results for 1975-76 were unavailable due to missing data.

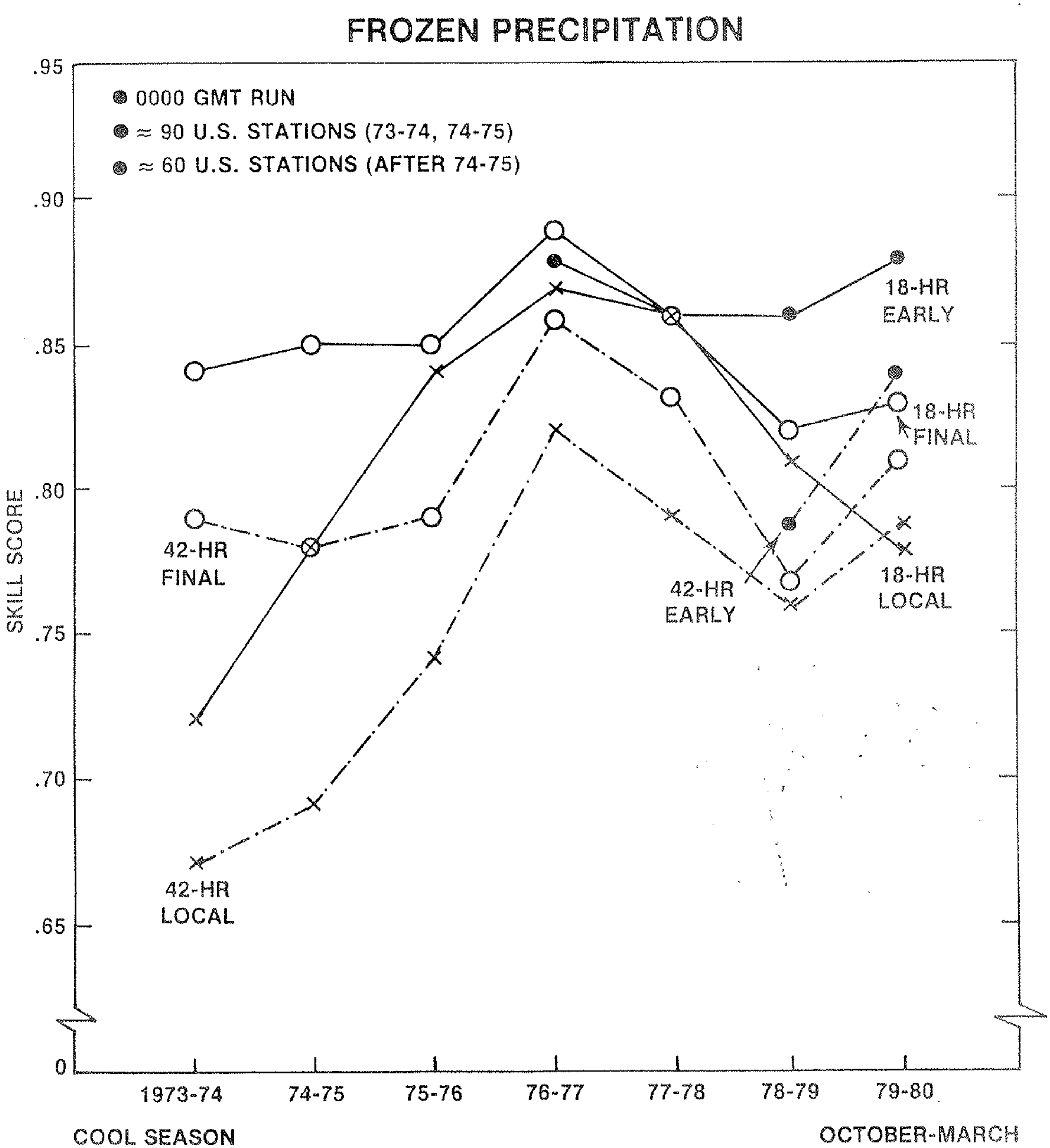

Fig. 3.1. The skill score for guidance and local forecasts of frozen precipitation.

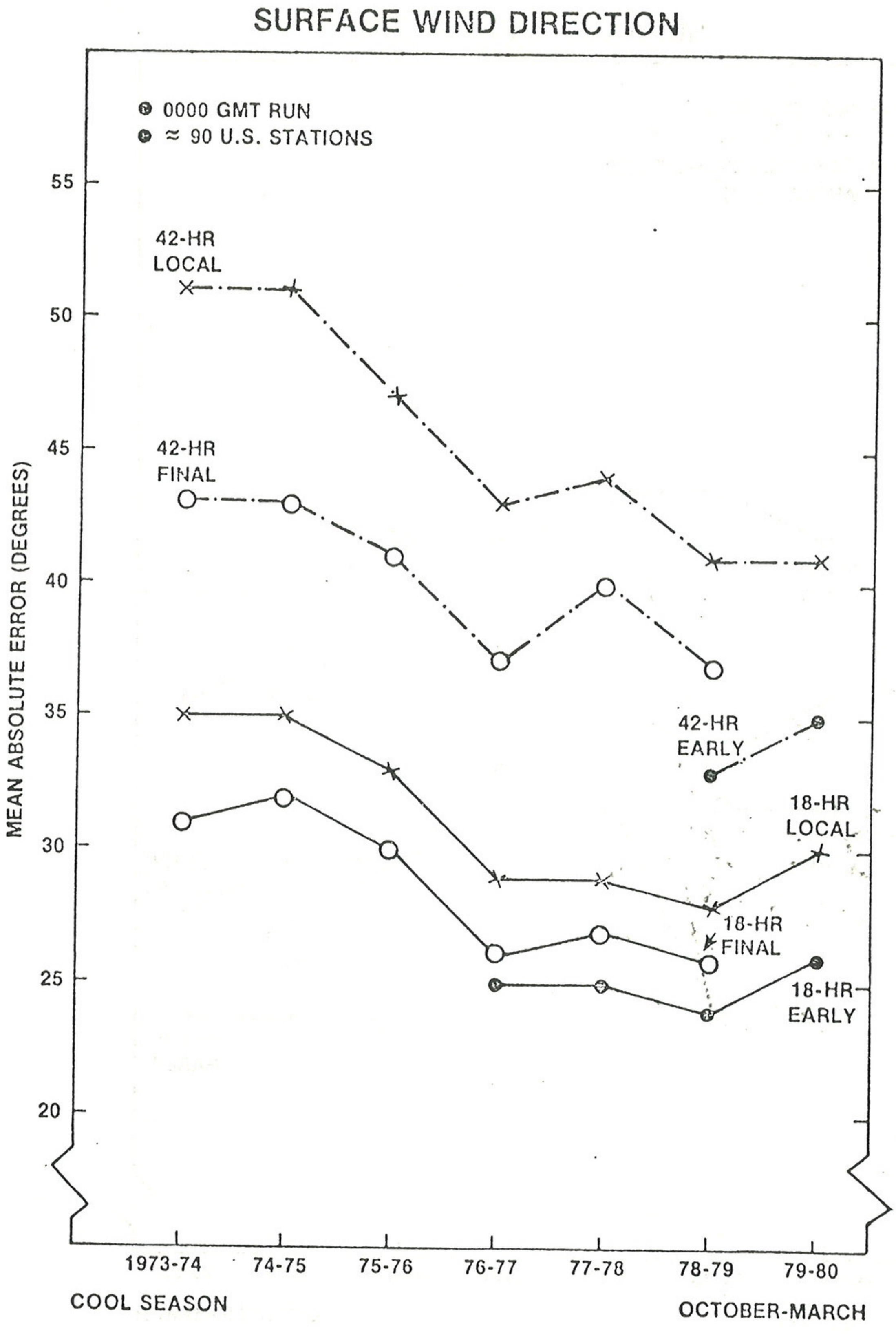

Fig. 4.1. Mean absolute errors for local and guidance surface wind direction forecasts for the cool season.

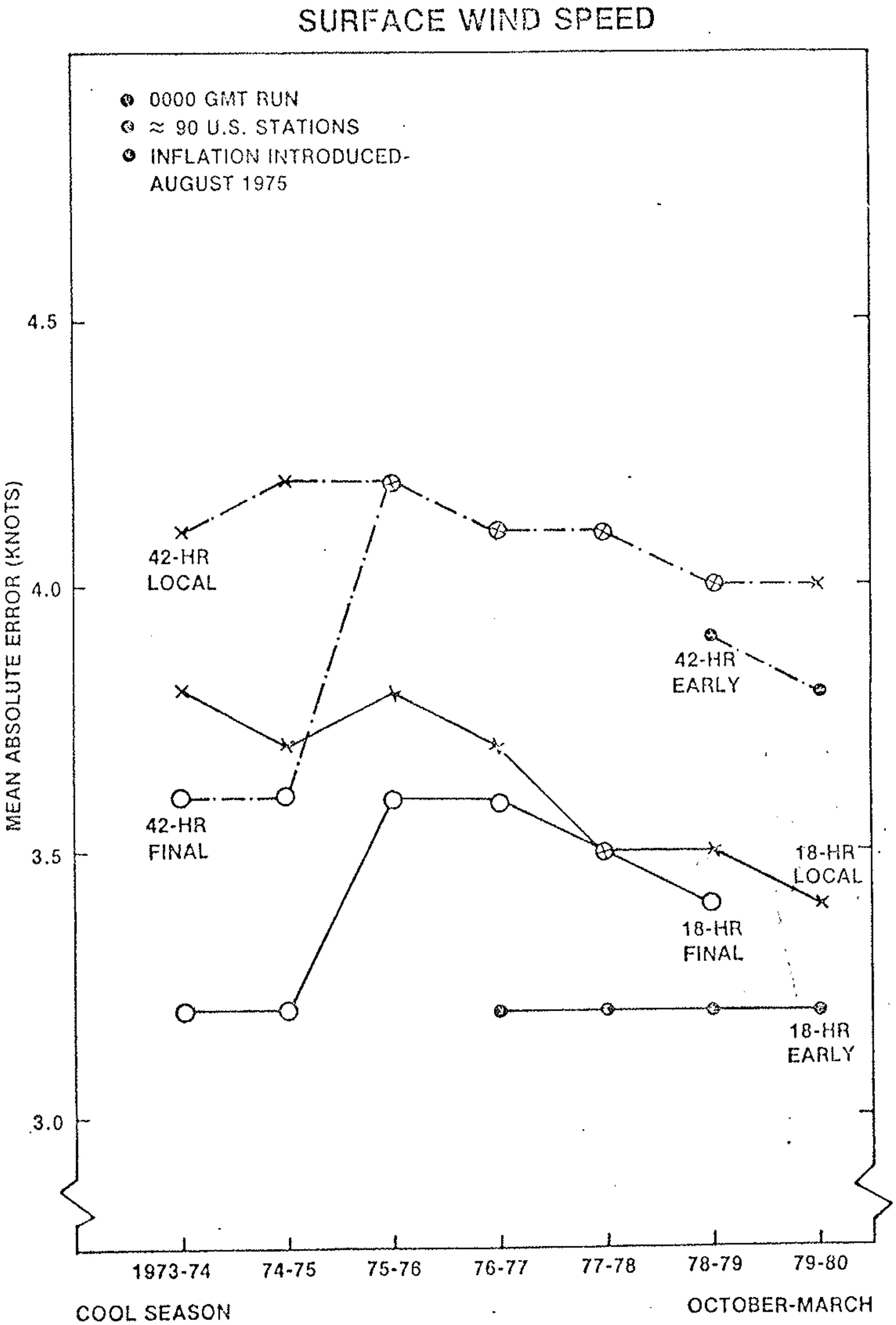

Fig. 4.2. Same as Fig. 4.1 except for wind speed forecasts.

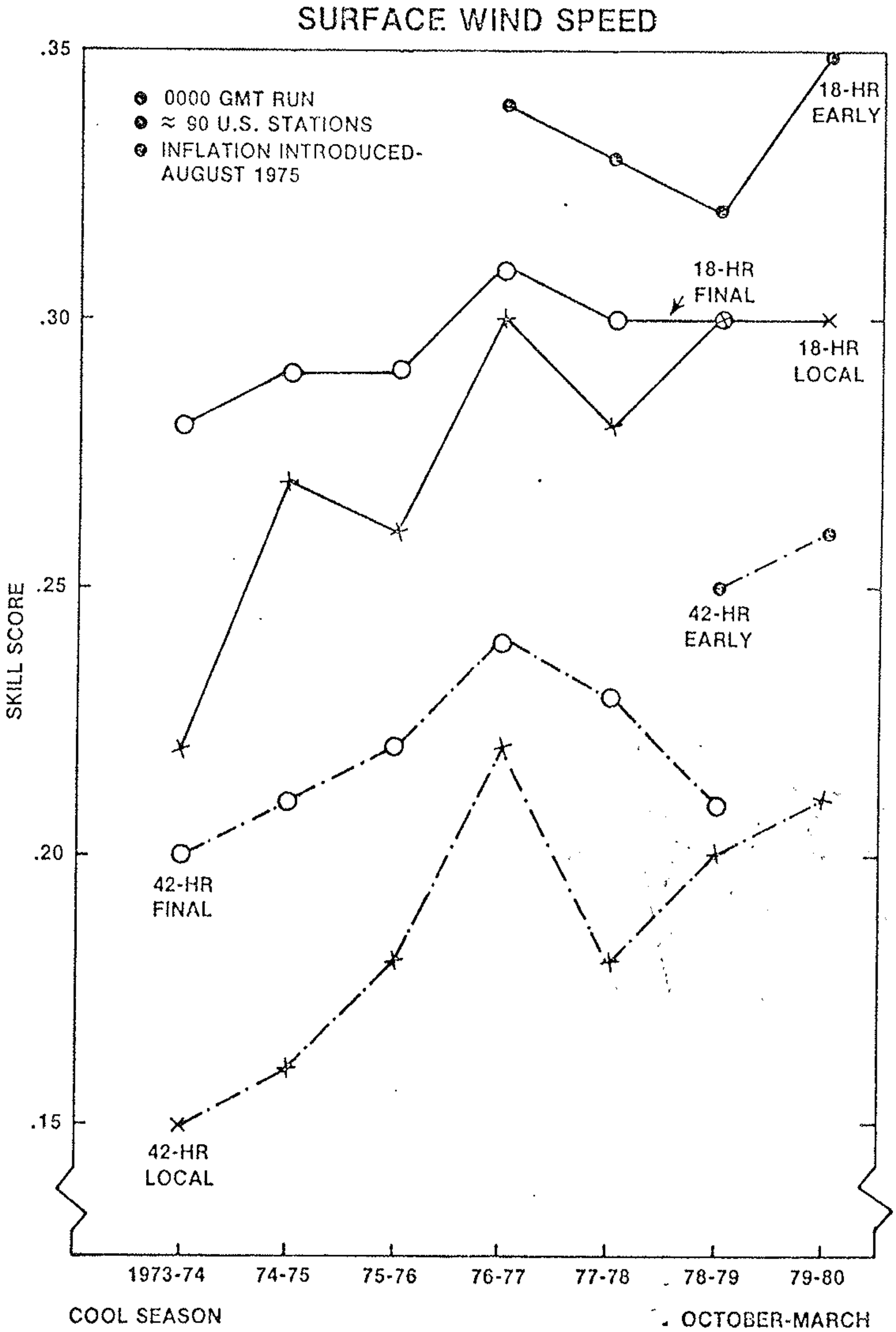

Fig. 4.3. Skill scores computed from five category contingency tables for local and guidance surface wind speed forecasts for the cool season.

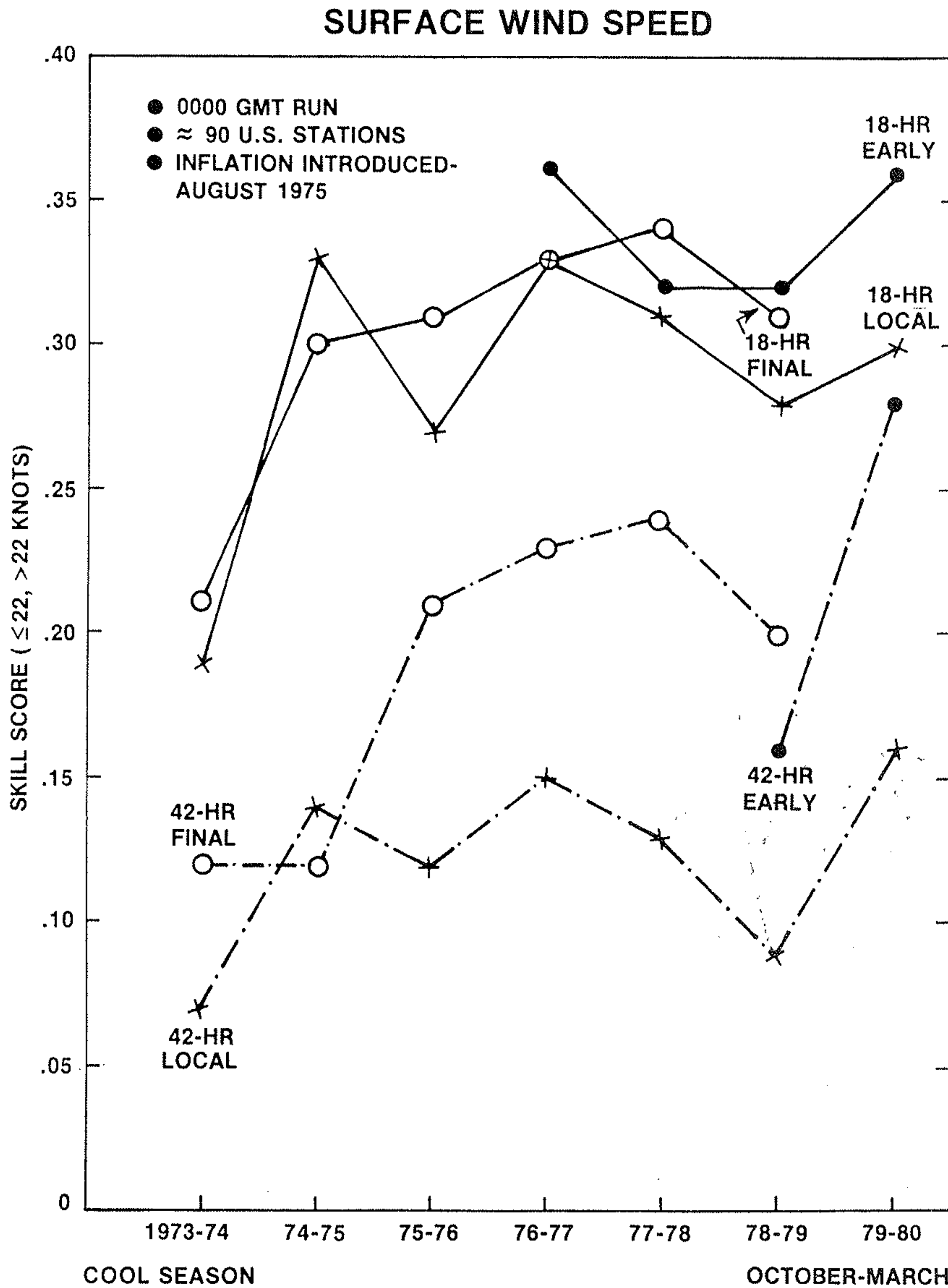

Fig. 4.4. Same as Fig. 4.3 except for two-category contingency tables.

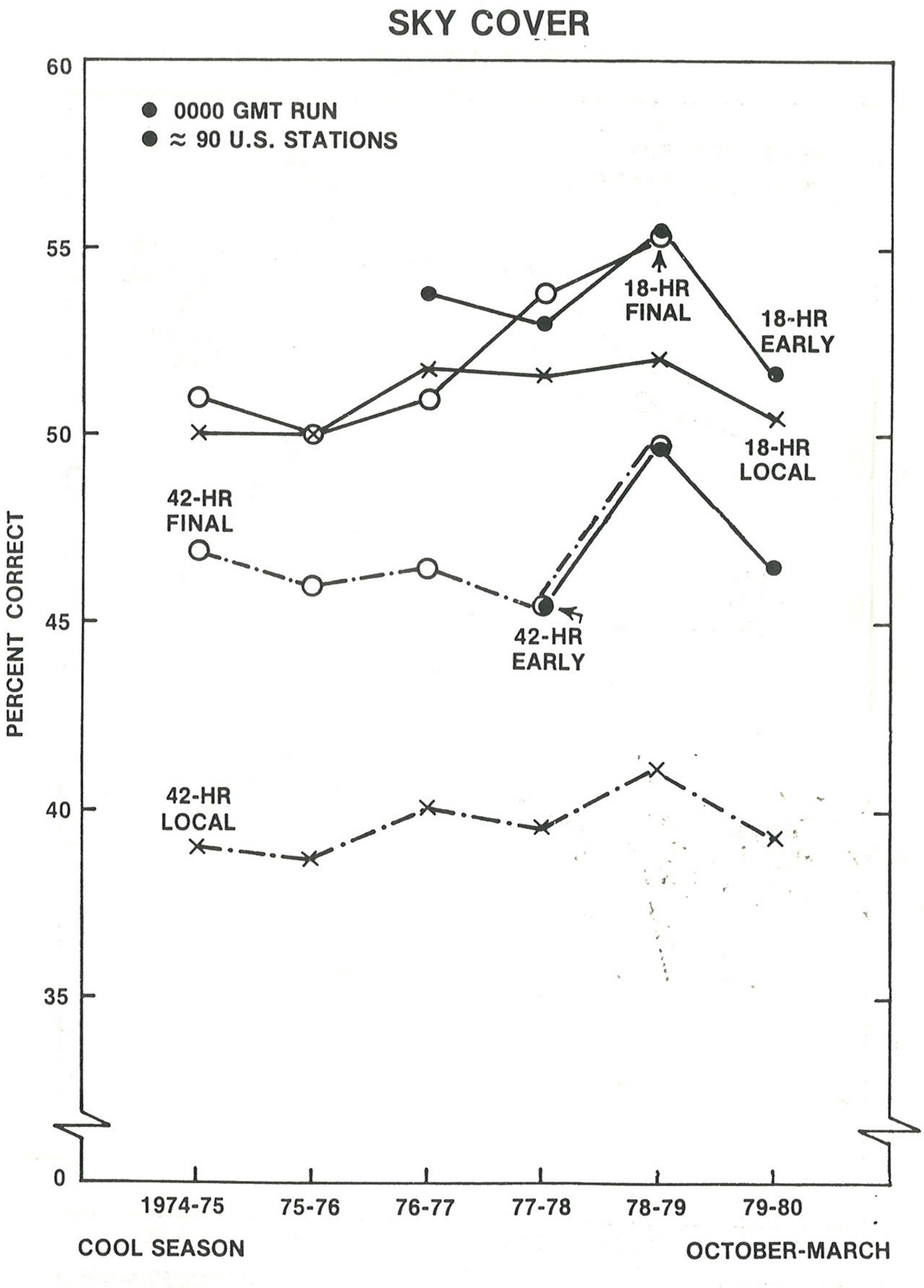

Fig. 5.1. Percent correct for local and guidance cloud amount forecasts for the cool season.

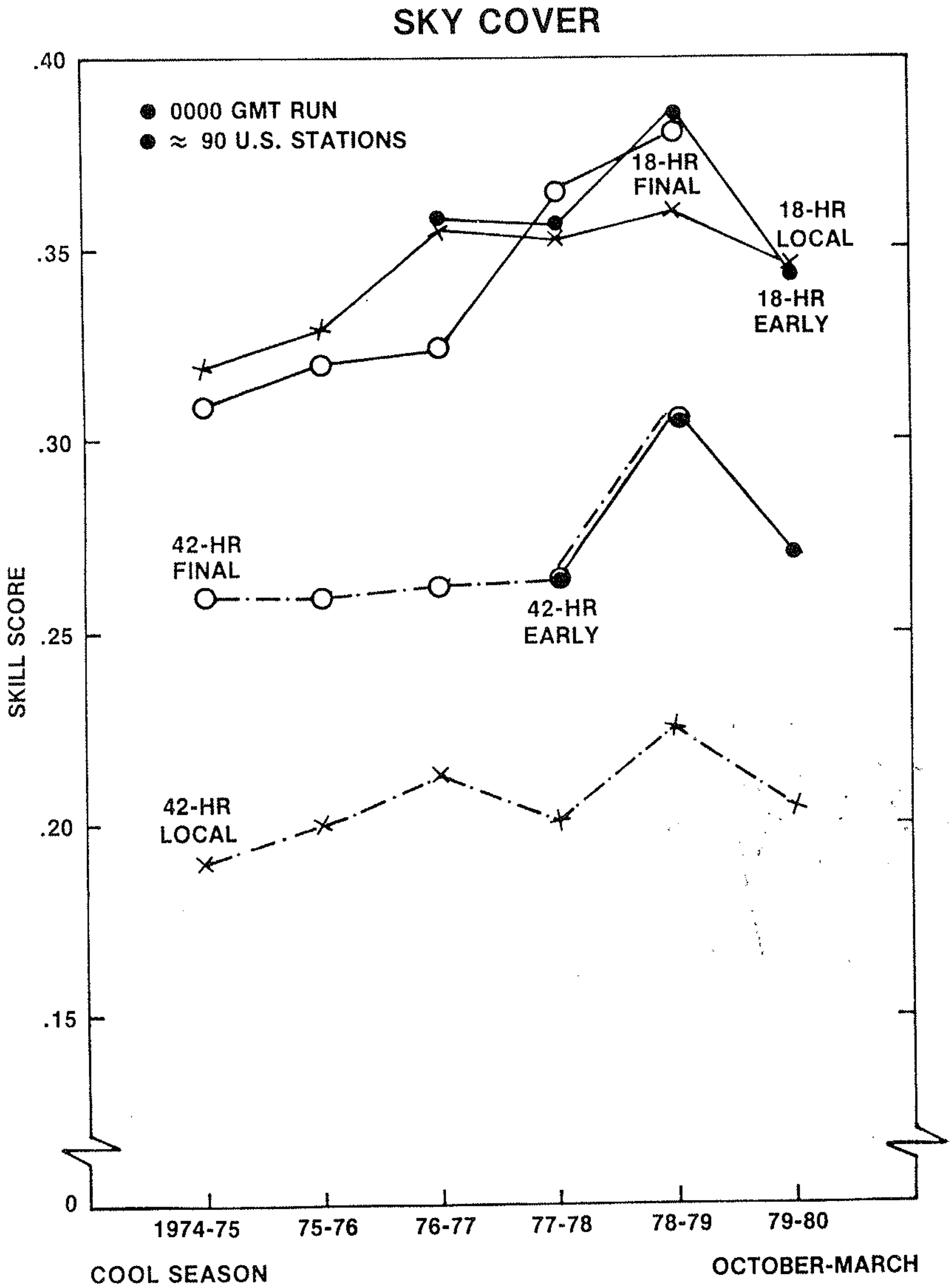

Fig. 5.2. Skill score for local and guidance cloud amount forecasts for the cool season.

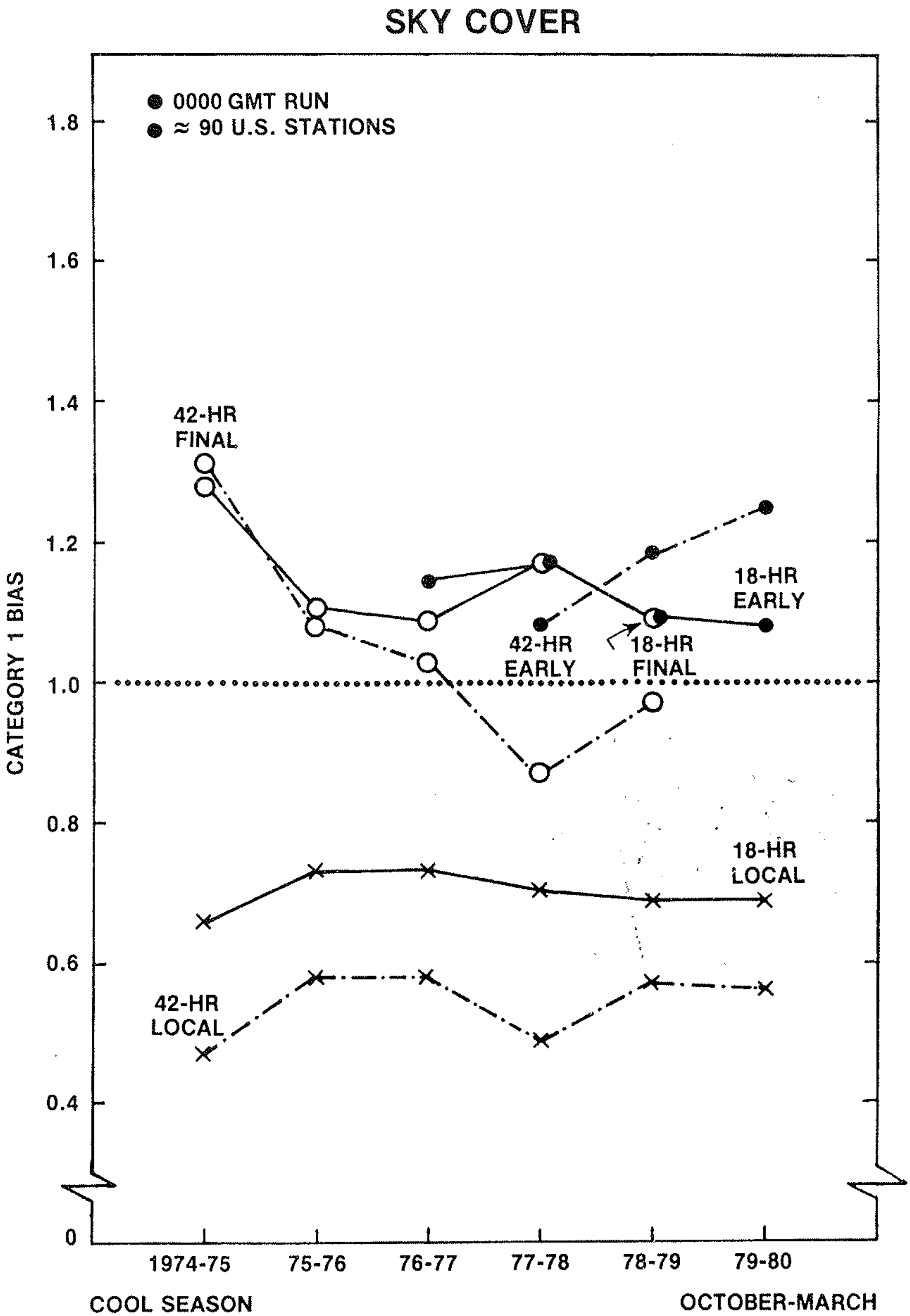

Fig. 5.3. Category 1 bias of the local and guidance cloud amount forecasts for the cool season.

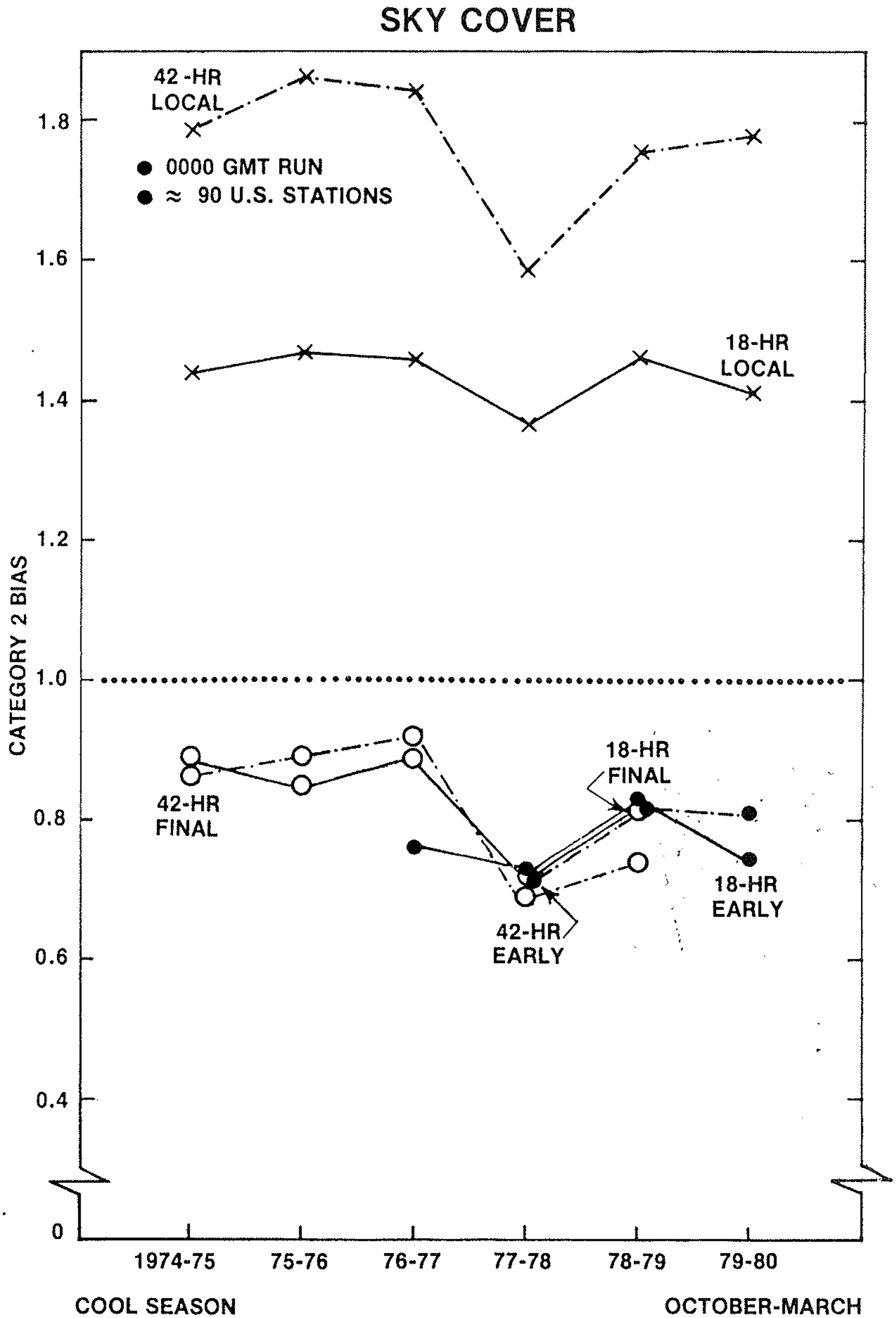

Fig. 5.4. Same as Fig. 5.3 except for category 2 bias.

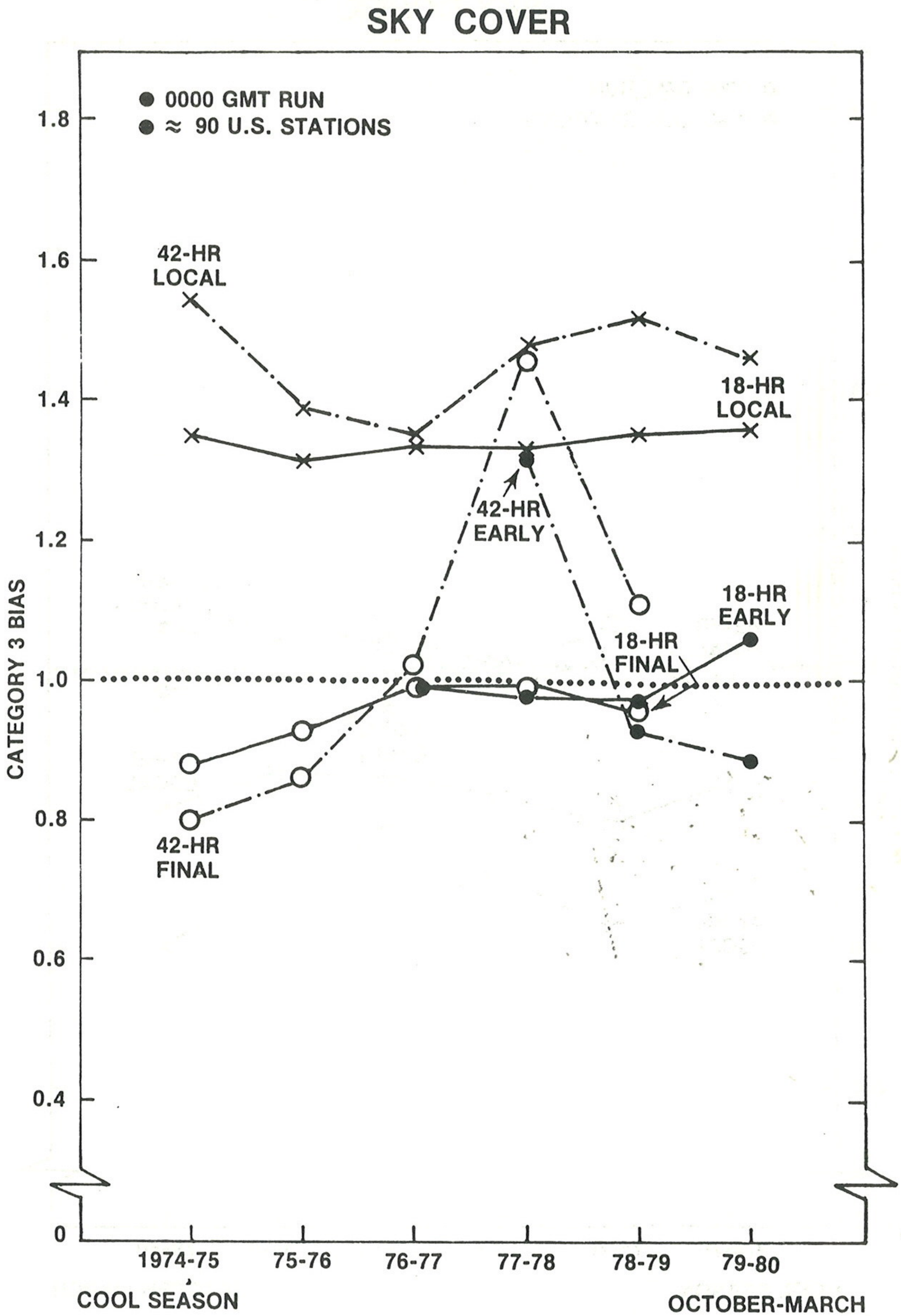

Fig. 5.5. Same as Fig. 5.3 except for category 3 bias.

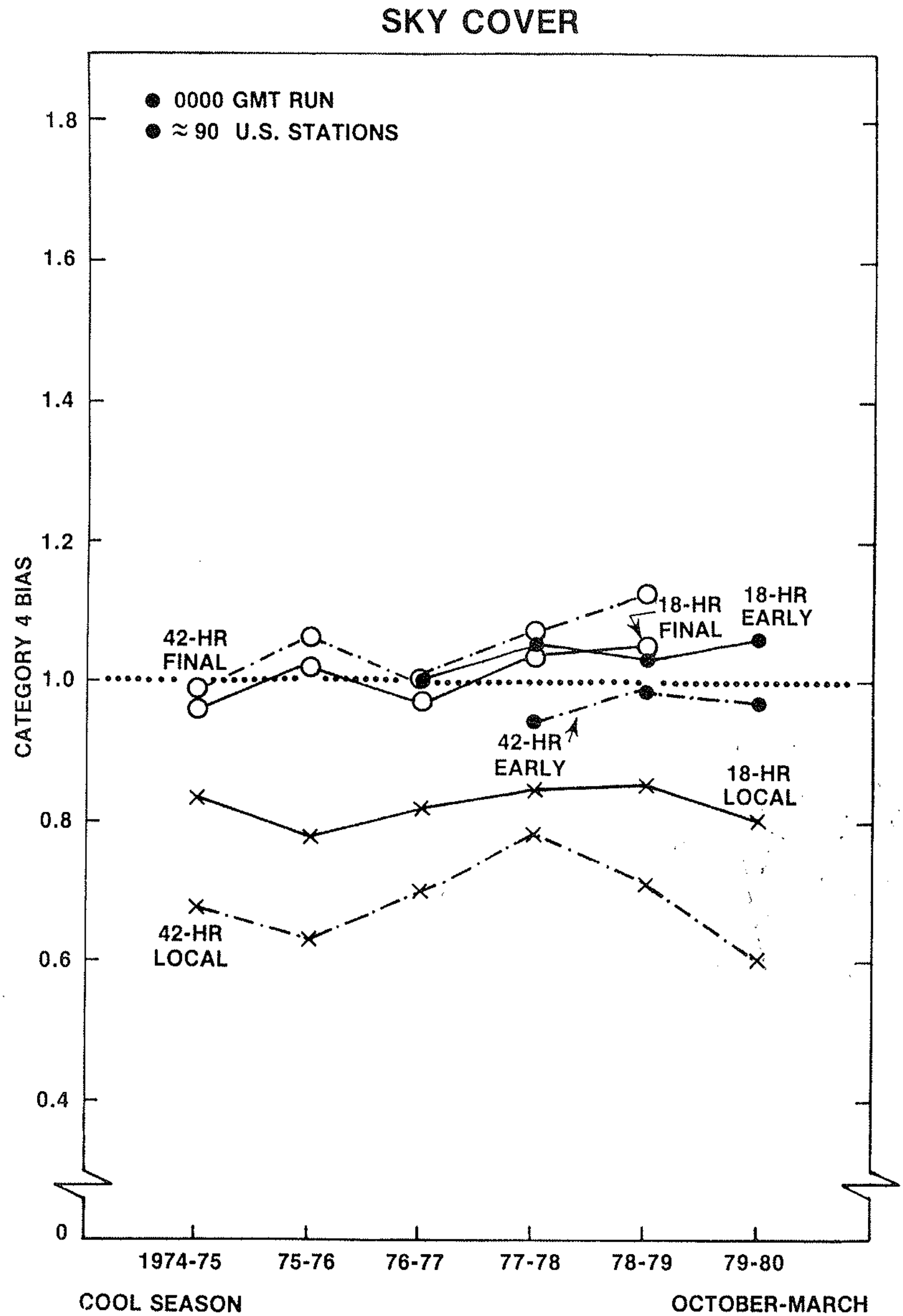

Fig. 5.6. Same as Fig. 5.3 except for category 4 bias.

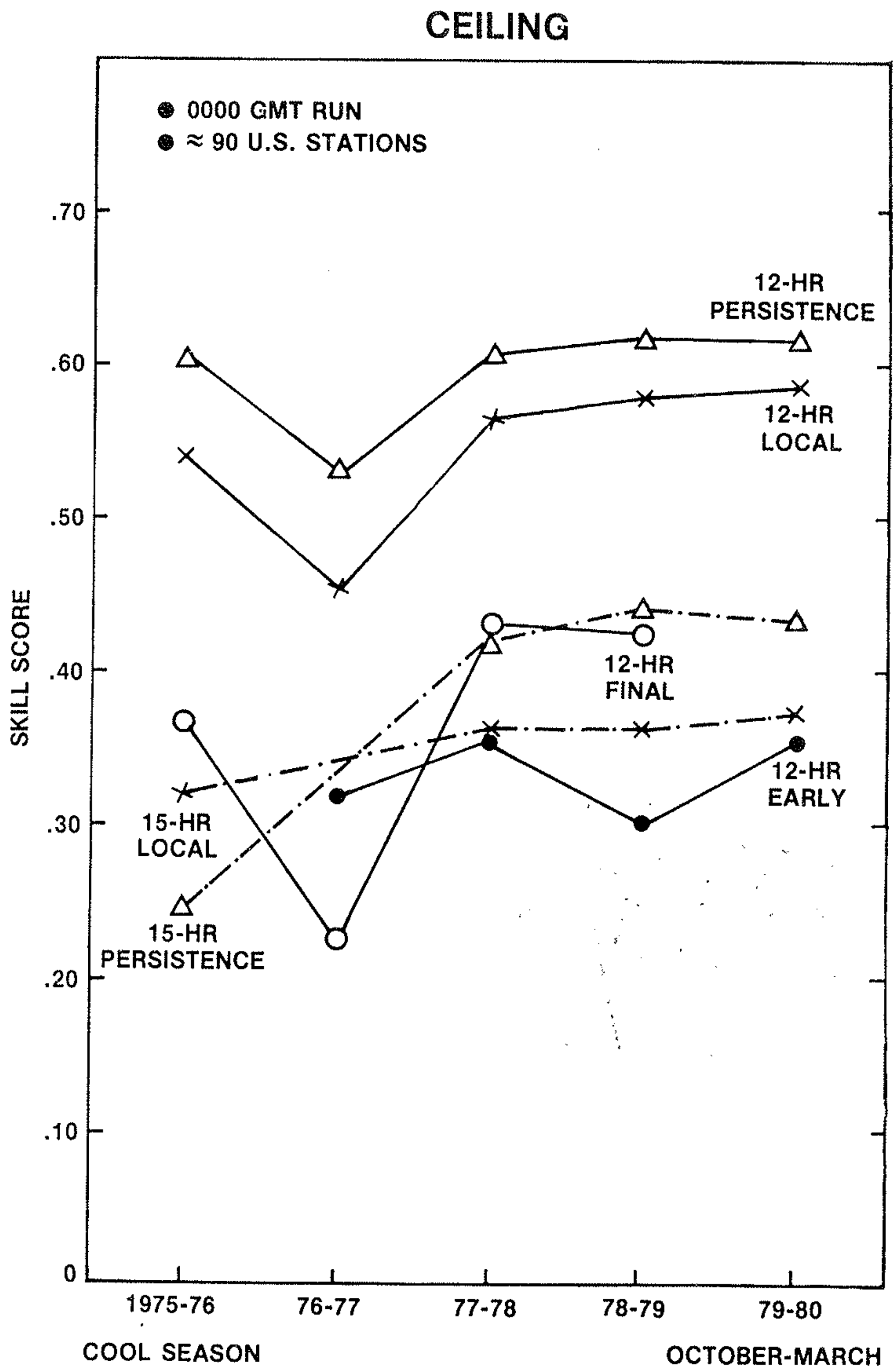

Fig. 6.1. Skill score computed from two-category contingency tables for guidance, local, and persistence ceiling forecasts for the cool season.

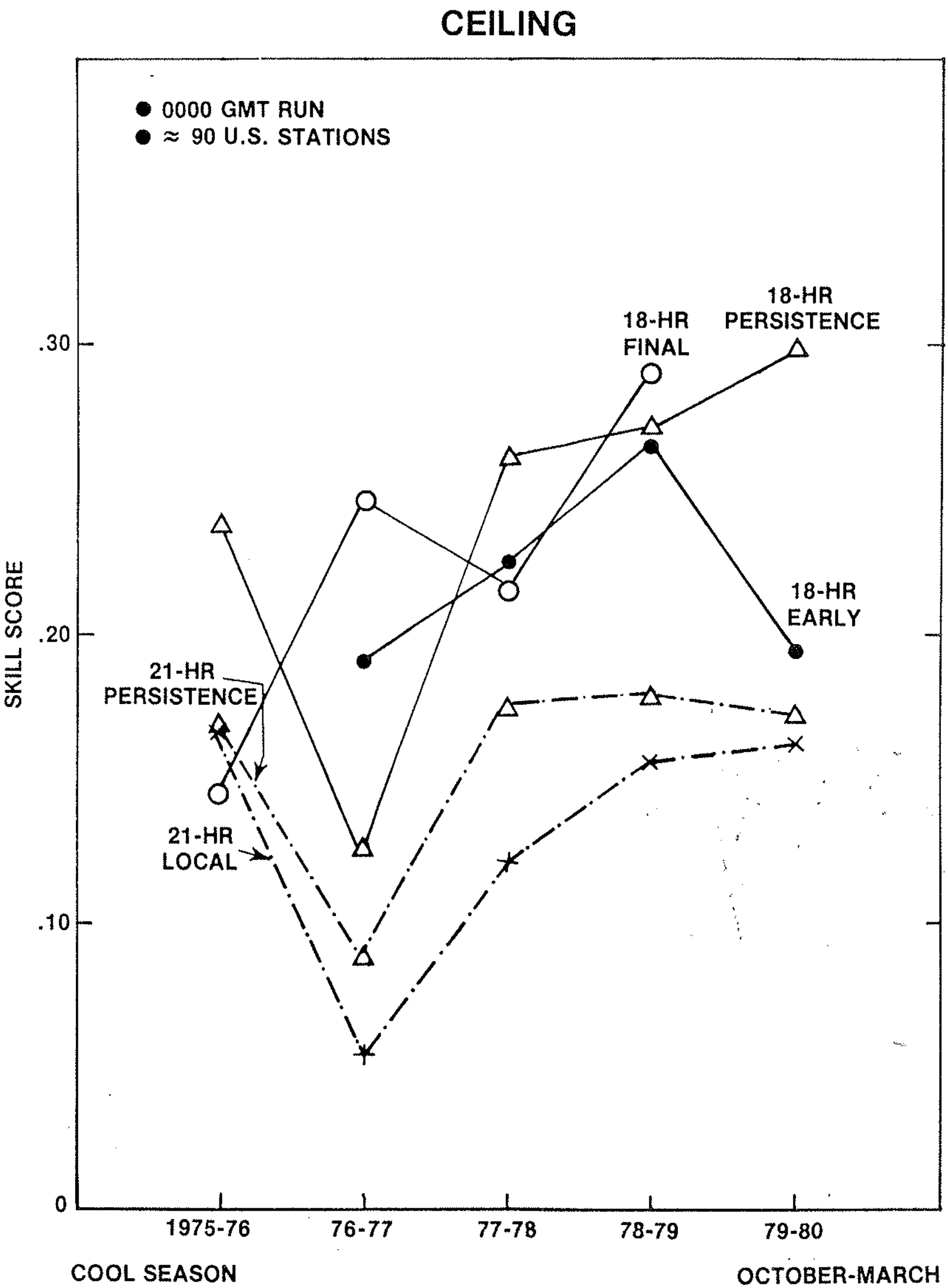

Fig. 6.2. Same as Fig. 6.1 except for forecast projection.

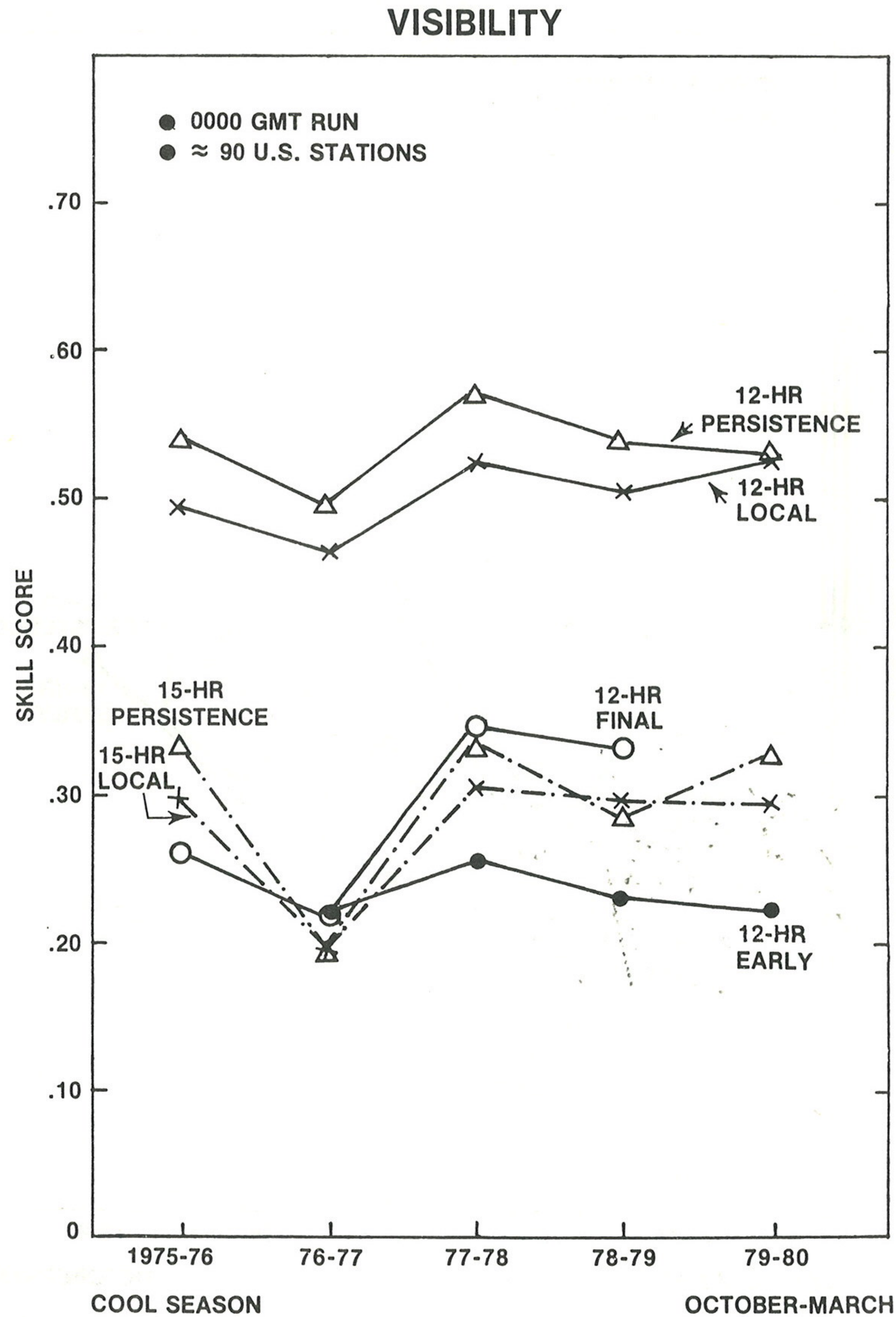

Fig. 6.3. Same as Fig. 6.1 except for visibility forecasts.

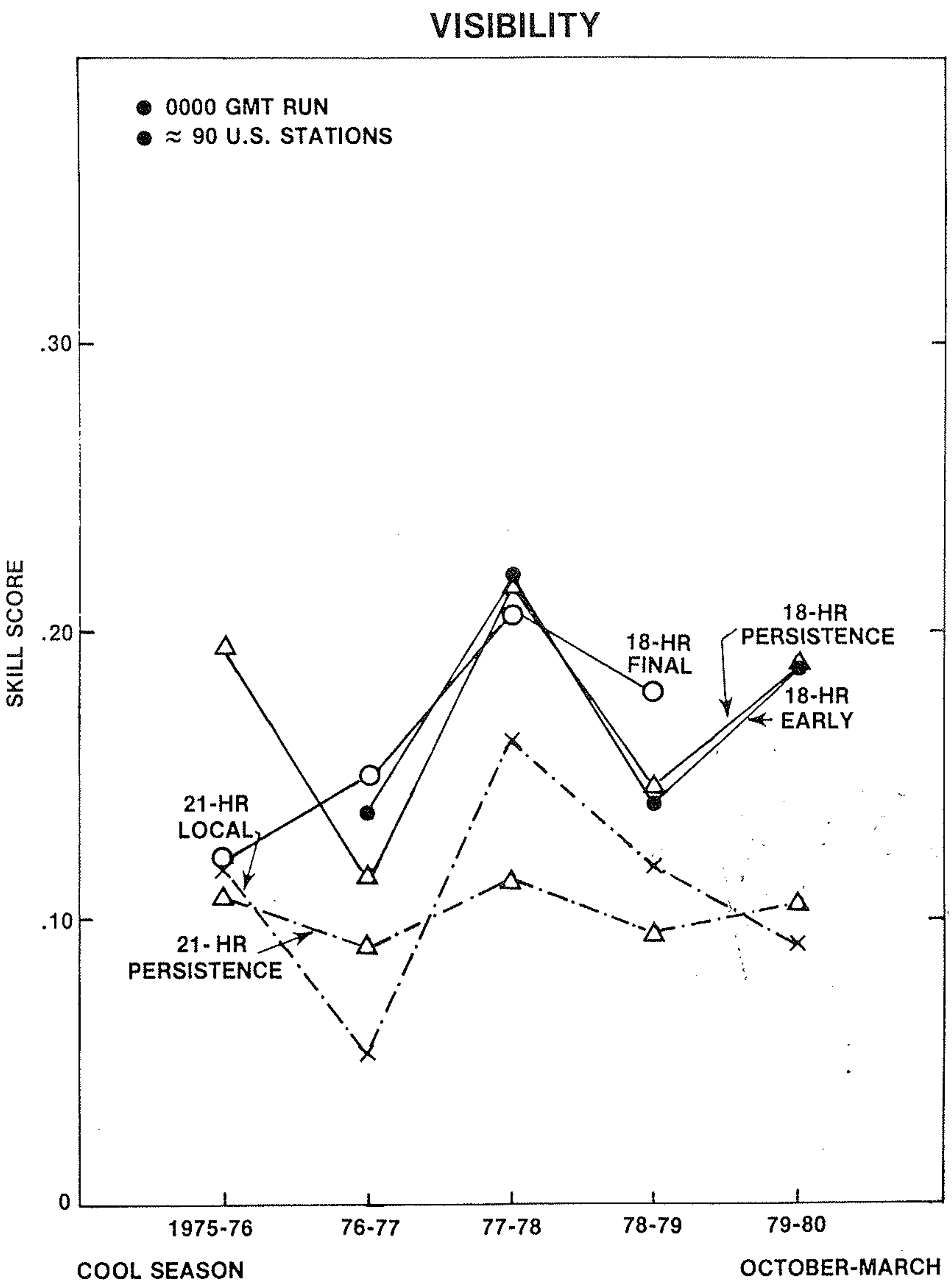

Fig. 6.4. Same as Fig. 6.3 except for forecast projection.

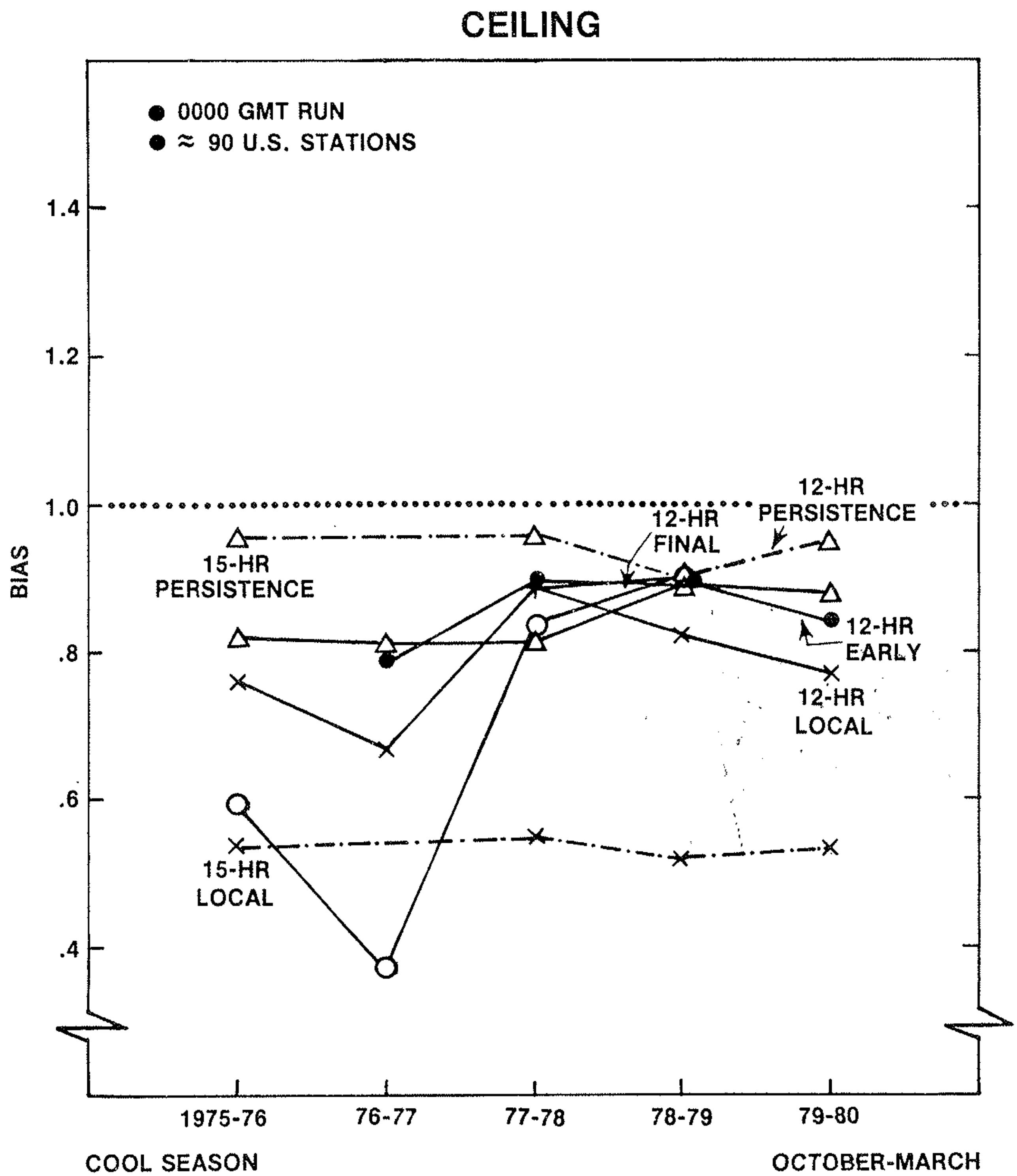

Fig. 6.5. Bias for categories 1 and 2 combined for guidance, local, and persistence ceiling forecasts for the cool season.

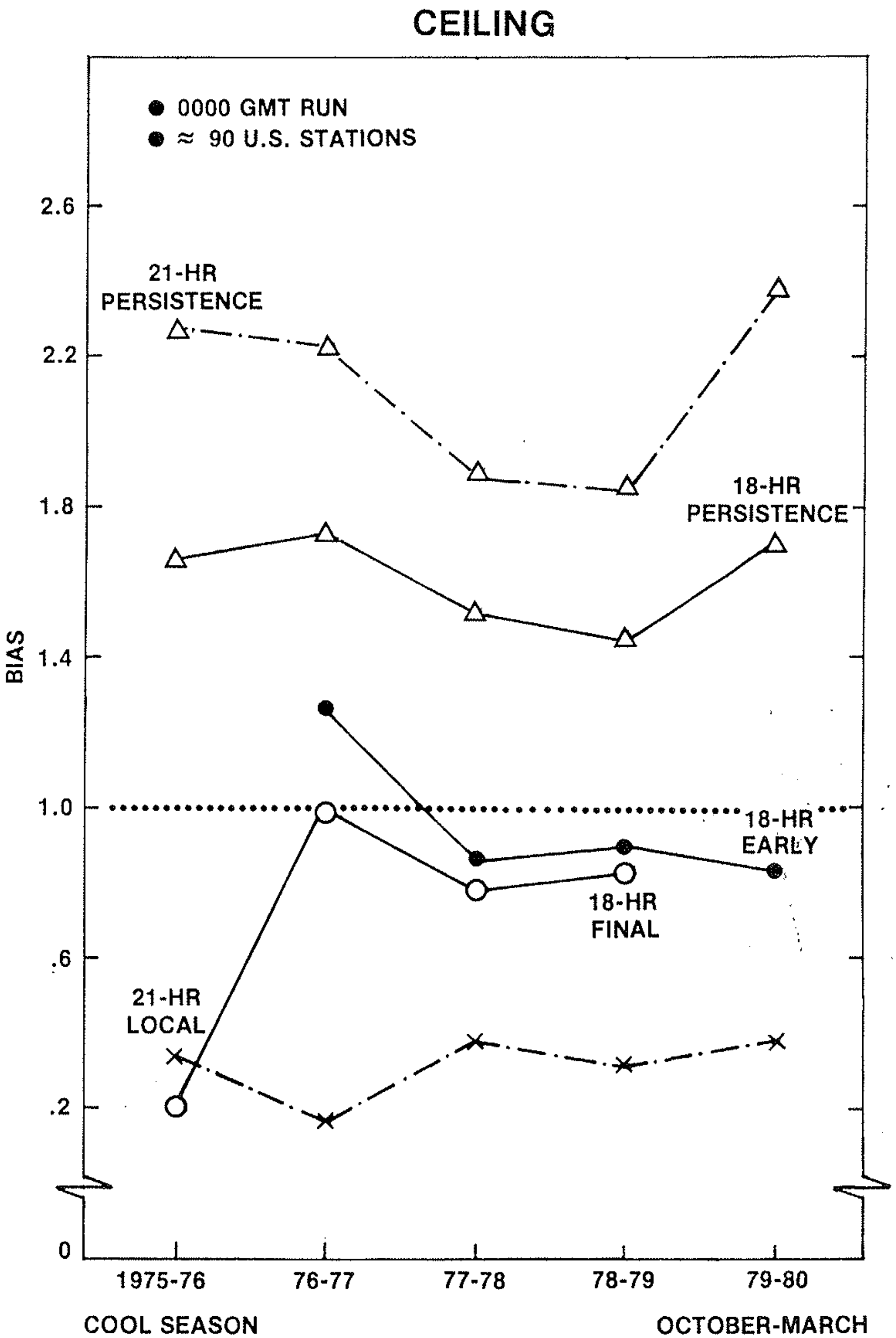

Fig. 6.6. Same as Fig. 6.5 except for forecast projection.

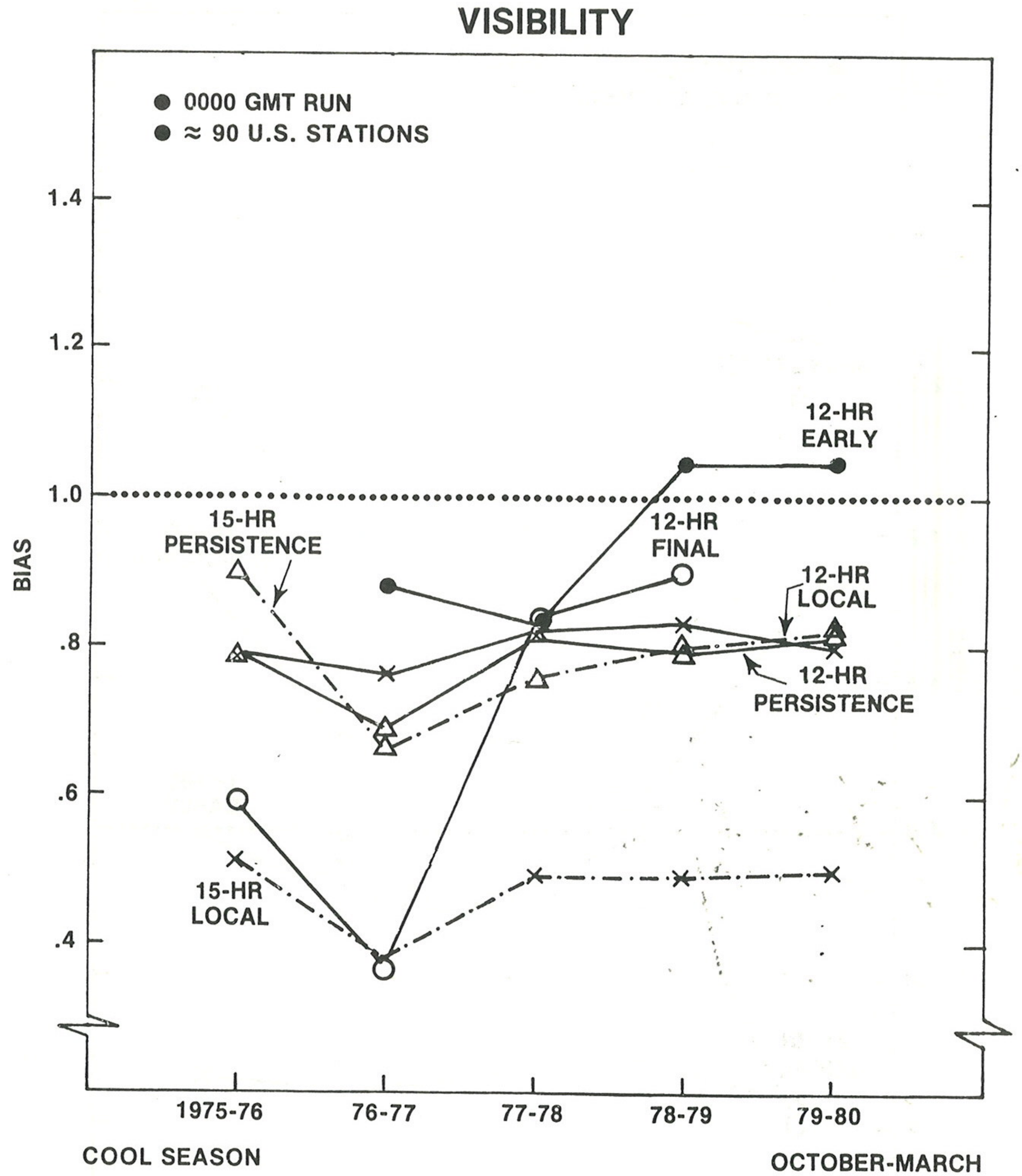

Fig. 6.7. Same as Fig. 6.5 except for visibility forecasts.

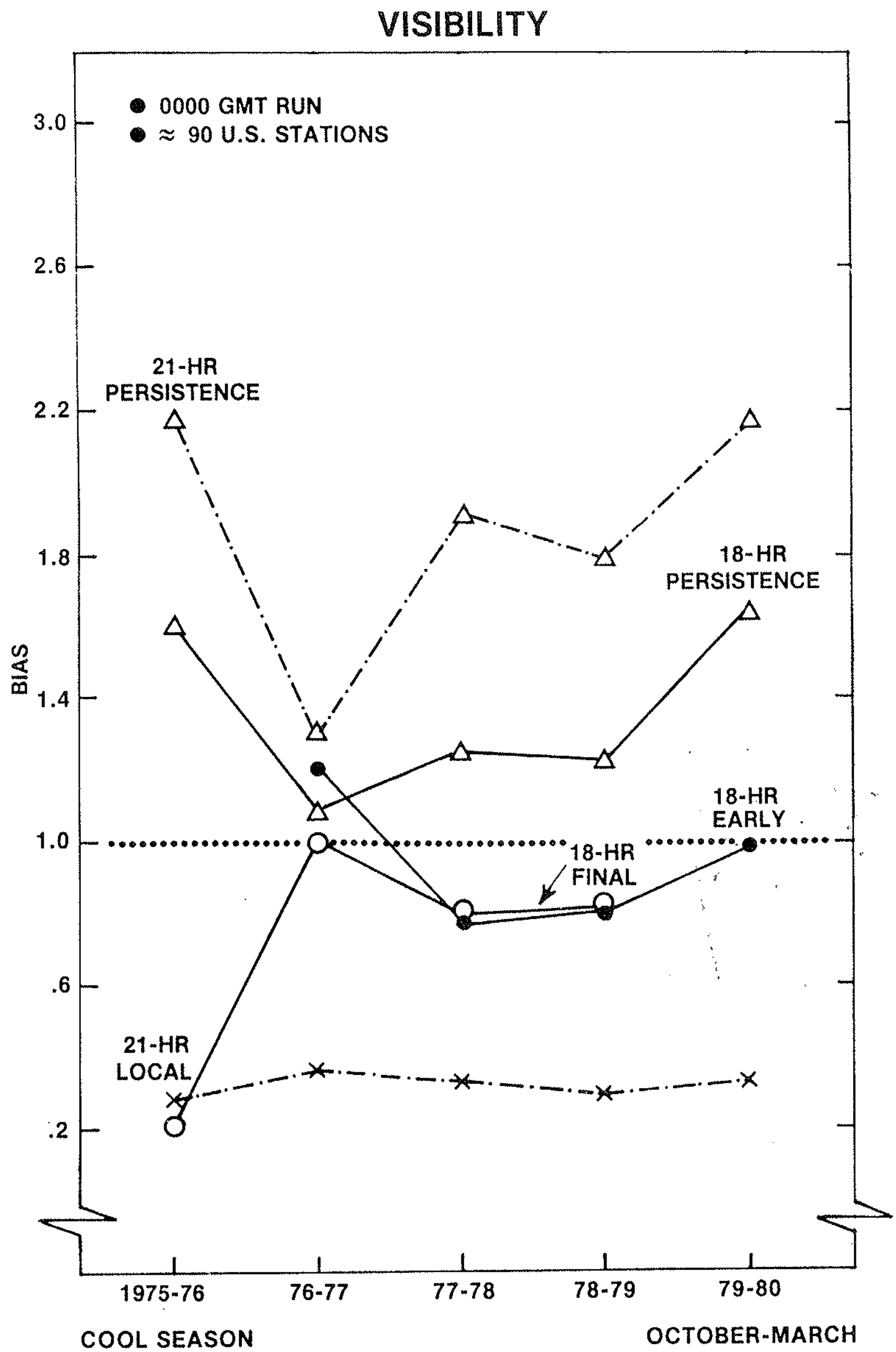

Fig. 6.8. Same as Fig. 6.7 except for forecast projection.

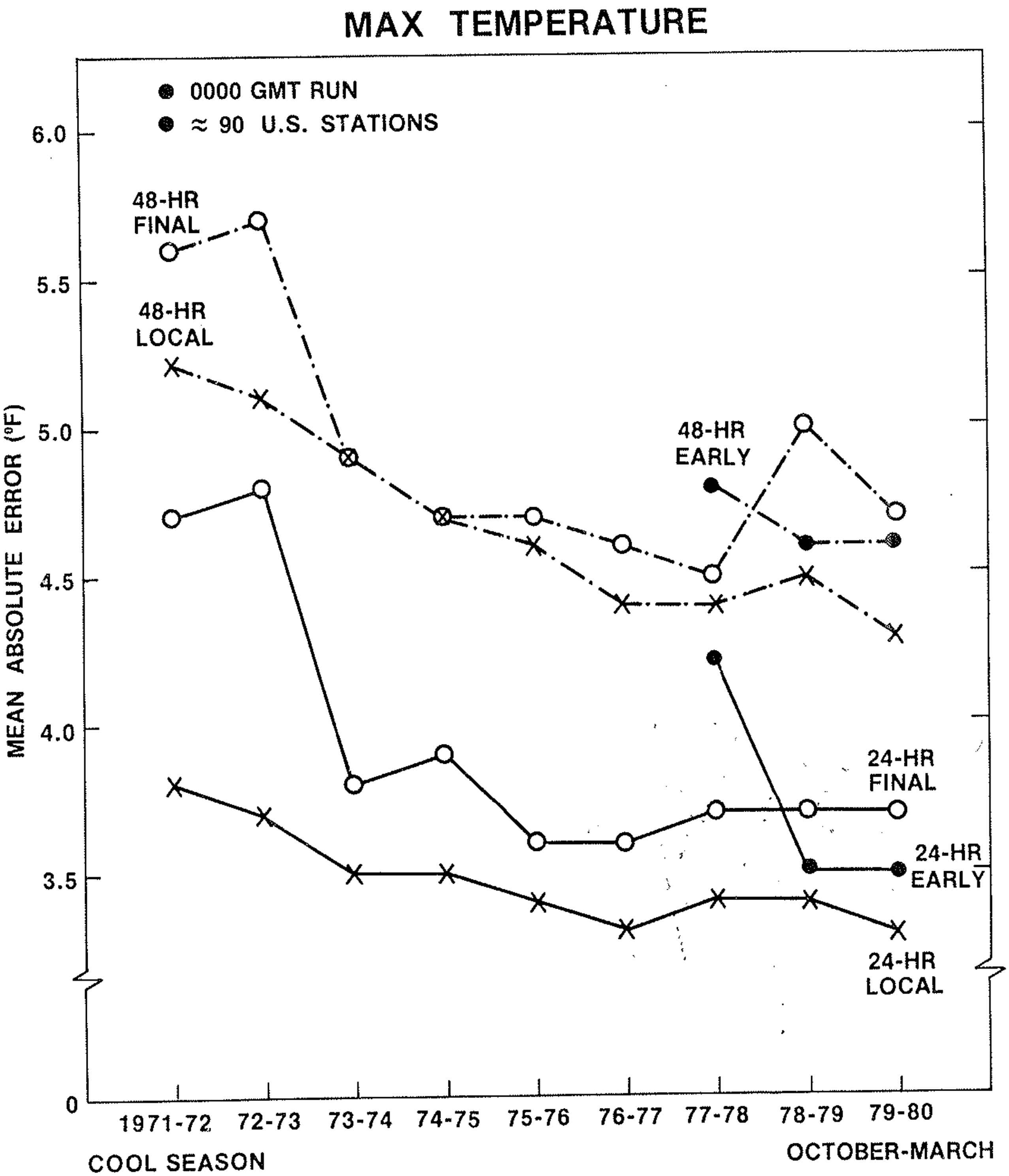

Fig. 7.1. Mean absolute errors of the local and guidance max temperature forecasts during the cool season.

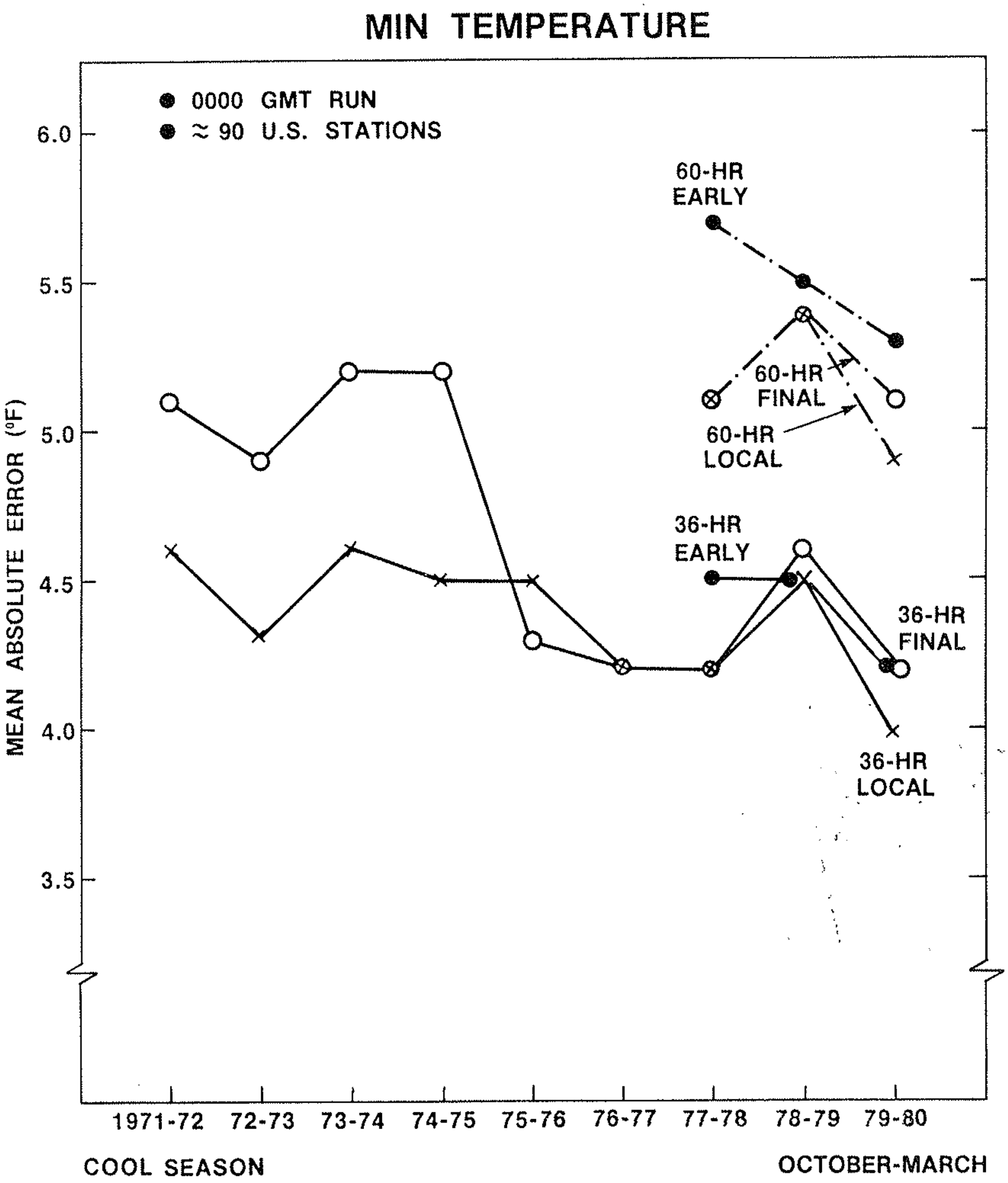

Fig. 7.2. Same as Fig. 7.1 except for the min temperature forecasts.